***MATTER: International Journal of Science and Technology***
***ISSN 2454-5880***

*Zel & Kongar, 2020*

*Volume 6 Issue 3, pp. 72-86*

*Date of Publication: 26th December 2020*

*DOI- https://doi.org/10.20319/mijst.2020.63.7286*

*This paper can be cited as: Zel, S., & Kongar, E. (2020). Influential Factors in Design and Implementation of Virtual Reality Technology. MATTER: International Journal of Science and Technology, 6(3), 72-86.*



# INFLUENTIAL FACTORS IN DESIGN AND IMPLEMENTATION OF VIRTUAL REALITY TECHNOLOGY

**Serap Zel**
*Technology Management, University of Bridgeport, Bridgeport, Connecticut, USA*
*serapzel@mybridgeport.edu*

**Elif Kongar, PhD**
*Mechanical Engineering and Technology Management, University of Bridgeport, Bridgeport, Connecticut, USA*
*kongar@bridgeport.edu*

---

## Abstract

*Virtual Reality (VR) is a computer-generated environment that creates a simulated experience for users. VR technology is used as an effective training tool, especially for teaching potentially dangerous and/or difficult-to-create scenarios in real-life. Despite the vast literature that shows the positive impact of VR training on the learners' performance and experience, studies that investigate the criteria for the selection of appropriate VR technology are quite limited. This paper proposes key decision criteria in selecting and investing in the right VR technology to create the best possible learning outcome based on the feedback from VR developers and engineers in the US. Ease of installation and creating an immersive user experience are identified as the most influential factors affecting the successful implementation of VR technology. We envision that this study will help companies that plan to invest in VR technologies better understand the critical factors affecting the successful design and implementation of the technology and hence will aid in decision making.*

**Keywords**

Technology Selection, Virtual Reality, User Experience, Decision Making

## 1. Introduction to Virtual Reality and User Experience

VR technology creates a unique digital landscape that users can interact with using their senses, such as sight, hearing, and touch. This technology is commonly accompanied by audio support provided via either headset or surrounds sound systems. Sound localization helps achieve a real-life like experience as sounds can originate from multiple locations and travel to different directions as necessitated by the virtual scenario. Additional devices such as voice recognition equipment can also be added into this setup to enhance the user experience increasing the level of active participation in the VR environment. In the virtual environment, optical, ultrasonic, and magnetic systems are tracked simultaneously to be able to reflect the right position and orientation of physical objects (Berg & Vance, 2017b). This design is vital to create the best view for users. The gestures and body movements of the users are translated into functional interaction techniques via gesture recognition algorithms (Mitra & Acharya, 2007). Some strong feedback mechanisms such as vibration, wind, or pressure might also be used to enhance the experience depending on the virtual reality scenario setup.

The human brain understands and experiences the world via senses. As Hungarian-born American illusionist, Harry Houdini said “What the eyes see and the ears hear, the mind believes.” VR technology imitates the world around us to create a very similar digital world that gives input to our sight, touch, and hearing senses. A capable and well-designed VR allows the human brain to read all senses in this virtual world, creating a real-world-like experience. With its continued rapid growth, the gaming industry became a leading source of virtual reality and augmented reality innovations helping to increase the accuracy and speed in position and gesture recognition in VR. With its widening market, virtual reality has been a popular technology used in e-commerce and a variety of additional industries, including tourism, military, healthcare, airlines, and educational services. The healthcare field uses VR training to train surgeons for high-risk procedures. Architects and interior designers utilize VR tools to design buildings or individual dwellings prior to the actual construction (Mobach, 2008). Retail companies benefit from VR while training retail store managers in anticipation of extraordinary activities to prepare salesforce for peak demand periods such as Black Friday or major seasonal events (Figure 1).

**Figure 1:** *Store Manager Training via Virtual Reality in Walmart (WTSP, 2018)*

VR experiences might also be designed for different purposes (Sherman & Craig, 2018), such as analyzing big data and solving problems in engineering, education, and healthcare industries (Huang, Rauch, & Liaw, 2010). On the other hand, VR applications can be designed to provide factual information to users regarding significantly large or small but complicated designs such as a building or a molecule. VR is a very useful tool to visualize complex and abstract information or problems and breakdown them into more meaningful parts to foster understanding, creativity and problem-solving ability.

## 2. Motivation

VR technologies are commonly used in healthcare, military, airline, and retail industries. The most common justification for its utilization is that VR provides a risk-free learning environment. Reflecting its increased utilization, the number of studies looking into its effects on the learning outcomes and experience is increasing steadily. Out of these, Wijewickrema et al. (2017) discussed and designed VR-based training for cochlear implant surgery. The authors concluded that the participants found VR training to be highly effective. 75% of participants indicated that this type of training was useful supplemental to other laboratory or operation room-based training. VR training is also used in building skills with emotionally or physically handicapped individuals. Smith et al. (2015) investigated the impact of virtual reality on job interview training using a sample group of young adult participants with high autism spectrum disorder (ASD) and compared the results with the control group. This study provided evidence that VR based training could be a useful intervention in preparing individuals with ASD for job interviews.

Even though the focus was not on VR technology, in one of the relevant studies, Goker and Karsak (2016) proposed a common weight data envelopment analysis (DEA) approach for selecting the most suitable advanced manufacturing technology. Similarly, Secundo et al. (2017) designed a selection methodology using a hybrid fuzzy extended Analytic Hierarchy Process (AHP) approach for service suppliers. In the VR technology market, there are many different versions, features, and differentiators of VR tools as well as different vendors. As the design and customization of VR training tools are costly, the selection of the right tool becomes a vital decision.

The existing studies in the literature search reveal VR as an efficient tool that adds value to user experience. In particular, the positive impact of VR technology on learning outcomes and the actual performance of learners are well documented. The literature also agrees on the benefits of VR on decision making and analyses. The common consensus is that technology facilitates faster and more efficient problem-solving.

Despite its proven benefits, however, there is a lack of research on how to select the appropriate VR tool. Aiming to address this gap, this study focuses on obtaining an answer to “What are the important decision criteria for selecting and investing in a VR tool?”. This paper provides a holistic view of VR utilization across industries aiming at identifying and consolidating relevant decision criteria for the selection of appropriate VR solutions. The sole focus of the study is on VR tools that are designed for individual experience via a head-mounted display with audio as is shown in Figure 2. That is the VR tools that allow multiple user interactions in a collaborative virtual environment such as VR based games are not considered.

**Figure 2:** *Head-Mounted Display (HMD)*
*(Marchionne, 2019)*

## 3. Literature Review

Understanding the dynamics in the VR design is important to analyze the rationale behind its adaption, which would aid in selecting the right VR solution. In the literature review, there is a focus on the impact of VR in impact on expected results and user experience in different fields such as construction, medical, and engineering as it is shown in Table 1. There is a higher number of researches focusing on decision-making frameworks in a software selection in general. However, decision making in virtual reality technology has not been investigated.

**Table 1:** *The Summary of Literature Review*

| No | Study | Authors | Aims | Methodology |
|---|---|---|---|---|
| 1 | Credibility and applicability of virtual reality models in design and construction | (Woksepp & Olofsson, 2008) | To investigate how VR models are experienced and assessed by the workforce | Qualitative and quantitative research (User survey) |
| 2 | Development and evaluation of a trauma decision-making simulator in Oculus virtual reality | (Harrington et al., 2018) | To develop and test the trauma decision-making simulator on individuals | Quantitative research (User survey) |
| 3 | Industry use of virtual reality in product design and manufacturing: a survey | (Berg & Vance, 2017b) | To describe the current state of the art of virtual reality as it is used as a decision-making tool in product design, particularly in engineering-focused businesses | Qualitative research |
| 4 | An Industry Case Study: Investigating Early Design Decision Making in Virtual Reality | (Berg & Vance, 2017a) | To present a case study of the use of VR as a design tool with a decision-making focus | Qualitative research & Case study |
| 5 | An integrated decision support system dealing with qualitative and quantitative objectives for enterprise software selection | (Şen, Baraçlı, Şen, & Başlıgil, 2009) | To create both qualitative and quantitative objectives to decide the right enterprise software | Quantitative research |

| | | | | |
|---|---|---|---|---|
| 6 | Data envelopment analysis based multi-objective optimization model for evaluation and selection of software components under optimal redundancy | (Gupta, Mehlawat, & Mahajan, 2018) | To build an optimization model to minimize the software cost and maximize the total value of purchasing through some constraints | Quantitative research |
| 7 | Supporting decision-making in service supplier selection using a hybrid fuzzy extended AHP approach | (Secundo, Magarielli, Esposito, & Passiante, 2017) | To present and apply a fuzzy extended analytic hierarchy process approach in the service supplier selection | Quantitative research & Case study |
| 8 | Application of an integrated multi-criteria decision making AHP-TOPSIS methodology for ETL software selection | (Hanine, Boutkhoum, Tikniouine, & Agouti, 2016) | To build a methodology that includes both AHP and TOPSIS techniques to select ETL software | Quantitative research |
| 9 | A decision support system for software technology selection | (Farshidi, Jansen, de Jong, & Brinkkemper, 2018) | To present a decision support system to help companies to choose the most suitable technology | Quantitative research & Case study |
| 10 | Virtual reality applications in manufacturing industries: Past research, present findings, and future directions | (Choi, Jung, & Noh, 2015) | To analyze the current literature on VR applications and discuss future trends | Literature review |
| 11 | Immediate effects of virtual reality mental practice in subjects with low back pain: A pilot study | (Tsai, Hsu, Hou, Chiu, & Sung, 2018) | To explore the immediate effects of virtual reality mental practice on low back pain | Quantitative research & User survey |

During the literature review, five important design factors that affect the adaptation of VR tools/platforms have been identified as it is shown in Table 2.

**Table 2:** *Five Design Factors Affecting Successful Implementation of VR Tool/Platform*

| **Factor** | **Definition** | **Related literature** |
|---|---|---|
| User Experience | VR tools help users to understand and interact with the simulated world. The design of the VR tool is vital to create the best possible user experience. The virtual environment should be believable and creating an immersive experience for the user. It should also be interactive that the user can move hands, arms, or legs to move and interact within the virtual environment. | (Bowman & McMahan, 2007) |
| Cost of the Platform | The main element in the total cost of VR tools is the hourly pay rates of VR design engineers. Therefore, if the VR tool to be designed is too complex and large-scale platform, then the cost is increased significantly. Additional to the VR design cost, there is also hardware cost and the post-production cost, which include the maintenance of the application, new features additions, or updates. However, the cost of VR tools (including head-mounted devices) seems to have a decreasing trend as the technology gains traction in the gaming industry. | (Hilfert & König, 2016)<br><br>(Yavrucuk, Kubali, & Tarimci, 2011) |
| Customizability | VR tools should be flexible enough to be customized based on the changing needs of users or businesses. Customizability helps the VR tool to keep up-to-date and effective in terms of expected impact on the user experience. Customization opportunity also gives users decision-making authority over technology and helps them to shape their own experiences. | (Feng et al., 2020)<br><br>(Turkay & Adinolf, 2015)<br><br>(Alankus, Lazar, May, & Kelleher, 2010) |

| | | |
|---|---|---|
| Ease of Installation and Use | Using VR tools should not require special skills for users. Users can vary according to gender, age group, and technology comfort levels. Installation and use should be designed considering the comfort of all user groups. Ease of installation and use is an important criterion to create the best possible user experience in the virtual environment. | (Young, Gaylor, Andrus, & Bodenheimer, 2014)<br><br>(Fagan, Kilmon, & Pandey, 2012)<br><br>(de Pougnadoresse, Bouvier, Herubel, & Biri, 2009) |
| User Support | In case of any troubleshooting needs of VR users, the proper user support should be available for users when needed. User support is needed during the installation and setting up the device(s) as well as an unexpected problem during the use of the VR tool. | (Mandal, 2013)<br><br>(Hanson & Shelton, 2008)<br><br>(Sutcliffe & Kaur, 2000) |

## 4. Methodology

In this paper, we employed a quantitative research methodology. Creating the basis for a data-driven methodology, a questionnaire is constructed to get the opinions of VR experts. Selected VR experts include engineers, developers, and team leaders who are experienced in designing VR tools and platforms. In the questionnaire, seven questions in which three open-ended are asked. Five design factors that are mentioned in the literature review are also asked VR experts in the questionnaire.

The questionnaire is sent to 45 VR engineers in the U.S. 37 out of 45 participants responded to the questionnaire. The demographics of the participants are shown in Table 3.

**Table 3:** *Demographics of Participants*

| | | N | P |
|---|---|---|---|
| ***Current role*** | VR Engineer/Developer | 30 | 81% |
| | Team Leader of VR Engineers | 5 | 14% |
| | Other | 2 | 5% |
| ***Experience level*** | 0-3 years | 16 | 43% |
| | 4-6 years | 15 | 41% |
| | +6 years | 6 | 16% |

| | | | |
|---|---|---|---|
| ***Industries they designed VR tools*** | Entertainment | 24 | 65% |
| | Education | 23 | 62% |
| | Product design/Marketing | 13 | 35% |
| | Healthcare | 11 | 30% |
| | Film | 7 | 19% |
| | Others | 6 | 16% |
| | Tourism | 4 | 11% |
| | Airlines | 2 | 5% |

The questionnaire is designed to accommodate responses based on a Likert-like scale (Arnold, McCroskey, & Prichard, 1967), which consists of five different levels, viz., Not Important At All, Not Important, Somewhat Important, Important, and Very Important. Each response is then assigned to a value ranging between 1 and 5, where 1 correlates with Not important at all, and 5 correlates with Strongly Agree (Table 4).

**Table 4:** *Numerical Scale in the Questionnaire*

| Response | Value |
|---|---|
| Not important at all | 1 |
| Not important | 2 |
| Somewhat important | 3 |
| Important | 4 |
| Very important | 5 |

## 5. Results

All participants agreed on the ease of installation and use is the most influential factor in the adaption of VR technology. The results from the questionnaire are provided in Tables 5 and 6. The second highest-rated criterion is user experience. VR platforms should be highly immersive and intuitive to use and control for users since it is desired to emulate how they act in real life. FPS (frames per second), lens resolution, comfort, visibility/clarity, immersiveness, and intuitiveness of controllers are other important design criteria in creating a better user experience in VR platforms. Participants mentioned that the hardware also plays a critical role in user experience as it translates the VR design to the user experience and brings freedom of movement and comfort. A participant mentioned that the success of the design is measured by how quickly users forget that they are in a VR headset. So, they feel and experience what they are like in the real world.

**Table 5:** *Participants' Responses in VR Design Criteria (Percentage)*

| Criteria | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| User experience | 0 | 9 | 12 | 38 | 41 |
| Cost of the platform | 0 | 9 | 49 | 31 | 11 |
| Customizability | 0 | 12 | 56 | 24 | 9 |
| Ease of installation & use | 0 | 0 | 11 | 34 | 54 |
| User support | 0 | 6 | 32 | 41 | 21 |

**Table 6:** *Participants' Responses in VR Design Criteria*

| Criteria | Standard deviation | Weighted average (out of 5) |
|---|---|---|
| User experience | 5.64 | 4.12 |
| Cost of the platform | 6.16 | 3.46 |
| Customizability | 6.62 | 3.29 |
| Ease of installation & use | 7.43 | 4.43 |
| User support | 5.27 | 3.76 |

When asked about the primary challenges of VR design, the questionnaire's respondents emphasized the importance of graphics performance as is shown in Table 7. Graphics need to be high quality but cannot slow down the frames per second because lagging can cause nausea and motion sickness on users. The second important challenge noted that the lack of awareness regarding this new technology as a potential factor that might hinder its acceptance in the marketplace. The third challenge was mentioned as identifying the real problem or need of end-users. They mentioned that getting the end-user to tell them clearly what they want is not always easy, end-users need training and explanation on the possibilities before they can tell VR developers what they need for their app or platform.

**Table 7:** *Participants' Responses in VR Design Challenges*

| Challenges that VR developers face | Percentage of total comments |
|---|---|
| Graphics performance: Balancing realism and functionality | 19% |
| Lack of end-users and user awareness | 16% |
| Defining end-users need/problem correctly | 14% |
| Current hardware limitations to provide the best user experience and functionality | 13% |
| High design cost / Lack of funding | 8% |

| | |
|---|---|
| Lack of end-user feedback because of the low use | 8% |
| High complexity in the design | 8% |
| Lack of expertise in VR design (It takes a long time to build skills and expertise for developers) | 6% |
| Ensuring ease of use for end-users | 5% |
| Lack of knowledge and sharing on VR best practices | 2% |
| Lack of good leadership in VR companies | 2% |
| Lack of after-sale support systems | 2% |

We also asked participants about in which areas there will be increased interest and use of VR tools in the next years. The results are shown in Figure 3. The training and education field was mentioned as the most important field to grow in the VR market. VR will be used in school's way more often, especially in combination with the ability to connect to classes remotely, as seen during the COVID-19 quarantine. Entertainment was mentioned as the second fast-growing area. The not only game industry but also the film industry will use VR more and more in the next years based on questionnaire responses.

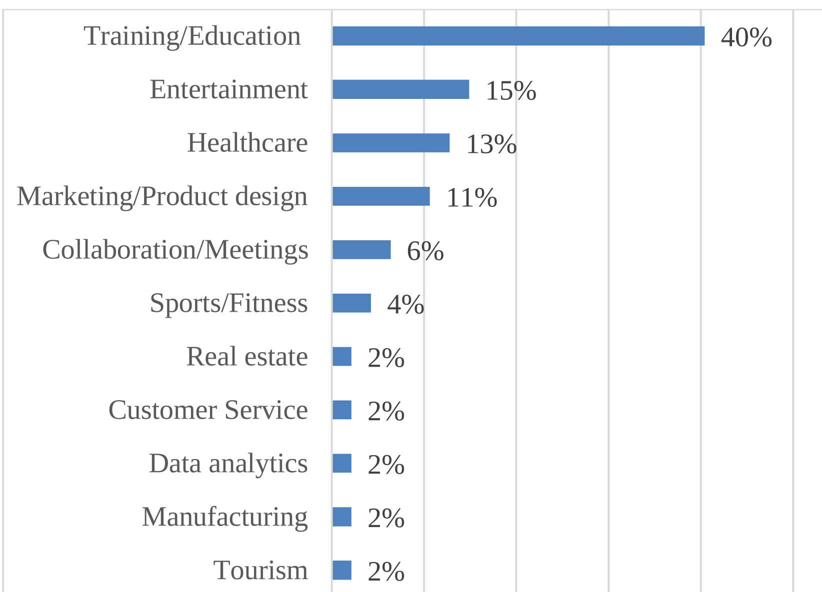


**Figure 3:** *Participants' Responses in the Growing Use of VR Tools in the Next Years*

## 6. Conclusion

VR technology requires hardware that is easy-to-use, ergonomic, and versatile. The technical features of the hardware, however, are not sufficient alone to meet market needs. The quality of the software that is in charge of creating a real life-like environment for the users is also a significant element in the acceptance of this emerging technology. An additional obstacle mentioned in the questionnaire stems from the relatively small size of this particular market. In this situation, there is a limited amount of end-user feedback on their experience in using VR tools. The current demand for VR is considerably small compared to a personal computer and gaming console market-making VR solutions, a financially risky proposition. Also, the VR market is progressing slowly due to the slow synchronization of the adoption of hardware, the production of tools, and the creation of content. The multi-platform environment, due to the existence of several options such as SteamVR, Oculus, Android, Windows MR, is creating an additional burden on the developers, increasing the uncertainty regarding which platforms to target.

As a concluding remark, it is anticipated that VR will be utilized more dominantly in training for simulation and processes that are not easy to create in real life, given that individuals retain information more effectively when they experience it. However, the industry would benefit from further investigation of potential markets and tasks where VR technology would be most beneficial. This naturally also requires consideration of potential future markets that are currently absent.

On the other hand, it is also vital to invest in building technical skills in designing VR tools to increase expertise in the VR market. As VR tools have a complex design and it is very hard to find universal automated test patterns to use with VR since the input is also very complex.

## 7. Limitations and Future Work

It is worth noting that the findings are based on a data-driven questionnaire and hence they are sensitive to the input received by the respondents. While the study could have benefited from a larger set of responses not only from VR developers but also from VR users, the research contributes to the related literature by introducing a set of criteria and providing real-life data obtained by VR design experts. Additionally, it would be beneficial to gather feedback from end-users who are experienced in using VR tools and platforms and companies that invested and implemented VR tools in their fields.

## REFERENCES

Alankus, G., Lazar, A., May, M., & Kelleher, C. (2010). Towards customizable games for stroke rehabilitation. Paper presented at the Proceedings of the SIGCHI conference on human factors in computing systems. https://doi.org/10.1145/1753326.1753649

Arnold, W. E., McCroskey, J. C., & Prichard, S. V. (1967). The Likert-Type Scale. https://doi.org/10.1080/01463376709368825

Berg, L. P., & Vance, J. M. (2017a). An industry case study: Investigating early design decision making in virtual reality. Journal of Computing and Information Science in Engineering, 17(1). https://doi.org/10.1115/1.4034267

Berg, L. P., & Vance, J. M. (2017b). Industry use of virtual reality in product design and manufacturing: a survey. Virtual reality, 21(1), 1-17. https://doi.org/10.1007/s10055-016-0293-9

Bowman, D. A., & McMahan, R. P. (2007). Virtual reality: how much immersion is enough? Computer, 40(7), 36-43. https://doi.org/10.1109/MC.2007.257

Choi, S., Jung, K., & Noh, S. D. (2015). Virtual reality applications in manufacturing industries: Past research, present findings, and future directions. Concurrent Engineering, 23(1), 40-63. https://doi.org/10.1177/1063293X14568814

de Pougnadoresse, F. d. S., Bouvier, P., Herubel, A., & Biri, V. (2009). From Research on the virtual reality installation. In Human-Computer Systems Interaction (pp. 335-345): Springer. https://doi.org/10.1007/978-3-642-03202-8_26

Fagan, M., Kilmon, C., & Pandey, V. (2012). Exploring the adoption of a virtual reality simulation. Campus-Wide Information Systems. https://doi.org/10.1108/10650741211212368

Farshidi, S., Jansen, S., de Jong, R., & Brinkkemper, S. (2018). A decision support system for software technology selection. Journal of Decision Systems, 27(sup1), 98-110. https://doi.org/10.1080/12460125.2018.1464821

Feng, Z., González, V. A., Mutch, C., Amor, R., Rahouti, A., Baghouz, A., . . . Cabrera-Guerrero, G. (2020). Towards a customizable immersive virtual reality serious game for earthquake emergency training. Advanced Engineering Informatics, 46, 101134. https://doi.org/10.1016/j.aei.2020.101134

Goker, N., & Karsak, E. E. (2016). An improved common weight DEA-based methodology for manufacturing technology selection. Paper presented at the Proceedings of the World Congress on Engineering and Computer Science.

Gupta, P., Mehlawat, M. K., & Mahajan, D. (2018). Data envelopment analysis based multi-objective optimization model for evaluation and selection of software components under optimal redundancy. Annals of Operations Research, 1-24. https://doi.org/10.1007/s10479-018-2984-y

Hanine, M., Boutkhoum, O., Tikniouine, A., & Agouti, T. (2016). Application of an integrated multi-criteria decision making AHP-TOPSIS methodology for ETL software selection. SpringerPlus, 5(1), 263. https://doi.org/10.1186/s40064-016-1888-z

Hanson, K., & Shelton, B. E. (2008). Design and development of virtual reality: analysis of challenges faced by educators. Journal of Educational Technology & Society, 11(1), 118-131.

Harrington, C. M., Kavanagh, D. O., Quinlan, J. F., Ryan, D., Dicker, P., O'Keeffe, D., . . . Tierney, S. (2018). Development and evaluation of a trauma decision-making simulator in Oculus virtual reality. The American Journal of Surgery, 215(1), 42-47. https://doi.org/10.1016/j.amjsurg.2017.02.011

Hilfert, T., & König, M. (2016). Low-cost virtual reality environment for engineering and construction. Visualization in Engineering, 4(1), 2. https://doi.org/10.1186/s40327-015-0031-5

Huang, H.-M., Rauch, U., & Liaw, S.-S. (2010). Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. Computers & Education, 55(3), 1171-1182. https://doi.org/10.1016/j.compedu.2010.05.014

Mandal, S. (2013). Brief introduction of virtual reality & its challenges. International Journal of Scientific & Engineering Research, 4(4), 304-309.

Marchionne, F. (2019). Virtual Reality Rehabilitation – The Future of Physical Therapy. Retrieved from https://imotions.com/blog/virtual-reality-rehabilitation/

Mitra, S., & Acharya, T. (2007). Gesture recognition: A survey. IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), 37(3), 311-324. https://doi.org/10.1109/TSMCC.2007.893280

Mobach, M. P. (2008). Do virtual worlds create better real worlds? Virtual reality, 12(3), 163-179. https://doi.org/10.1007/s10055-008-0081-2

Secundo, G., Magarielli, D., Esposito, E., & Passiante, G. (2017). Supporting decision-making in service supplier selection using a hybrid fuzzy extended AHP approach. Business Process Management Journal. https://doi.org/10.1108/BPMJ-01-2016-0013

Şen, C. G., Baraçlı, H., Şen, S., & Başlıgil, H. (2009). An integrated decision support system dealing with qualitative and quantitative objectives for enterprise software selection. Expert systems with applications, 36(3), 5272-5283. https://doi.org/10.1016/j.eswa.2008.06.070

Sherman, W. R., & Craig, A. B. (2018). Understanding virtual reality: Interface, application, and design: Morgan Kaufmann. https://doi.org/10.1016/B978-0-12-800965-9.00010-6

Smith, M. J., Fleming, M. F., Wright, M. A., Losh, M., Humm, L. B., Olsen, D., & Bell, M. D. (2015). Brief report: Vocational outcomes for young adults with autism spectrum disorders at six months after virtual reality job interview training. Journal of autism and developmental disorders, 45(10), 3364-3369. https://doi.org/10.1007/s10803-015-2470-1

Sutcliffe, A. G., & Kaur, K. D. (2000). Evaluating the usability of virtual reality user interfaces. Behaviour & Information Technology, 19(6), 415-426. https://doi.org/10.1080/014492900750052679

Tsai, Y., Hsu, H., Hou, Y., Chiu, Y., & Sung, W. (2018). Immediate effects of virtual reality mental practice in subjects with low back pain: A pilot study. Annals of Physical and Rehabilitation Medicine, 61, e483. https://doi.org/10.1016/j.rehab.2018.05.1128

Turkay, S., & Adinolf, S. (2015). The effects of customization on motivation in an extended study with a massively multiplayer online roleplaying game. Cyberpsychology: Journal of Psychosocial Research on Cyberspace, 9(3). https://doi.org/10.5817/CP2015-3-2

Wijewickrema, S., Copson, B., Zhou, Y., Ma, X., Briggs, R., Bailey, J., . . . O'Leary, S. (2017). Design and evaluation of a virtual reality simulation module for training advanced temporal bone surgery. Paper presented at the 2017 IEEE 30th international symposium on computer-based medical systems (CBMS). https://doi.org/10.1109/CBMS.2017.10

Woksepp, S., & Olofsson, T. (2008). Credibility and applicability of virtual reality models in design and construction. Advanced Engineering Informatics, 22(4), 520-528. https://doi.org/10.1016/j.aei.2008.06.007

WTSP. (2018). Walmart uses VR for Black Friday training. Retrieved from https://www.youtube.com/watch?v=U81GGDCN0a4

Yavrucuk, I., Kubali, E., & Tarimci, O. (2011). A low-cost flight simulator using virtual reality tools. IEEE Aerospace and Electronic Systems Magazine, 26(4), 10-14. https://doi.org/10.1109/MAES.2011.5763338

Young, M. K., Gaylor, G. B., Andrus, S. M., & Bodenheimer, B. (2014). A comparison of two cost-differentiated virtual reality systems for perception and action tasks. Paper presented at the Proceedings of the ACM Symposium on Applied Perception. https://doi.org/10.1145/2628257.2628261