Designing and Development of Educational Virtual Reality Campus – EVRECA[1]

Ali GERİŞ
Manisa Celal Bayar University

Nesrin ÖZDENER
Marmara Üniversity

Abstract

Purpose: There is increasing concern that the processes of designing and developing educational virtual reality environments are not carried out and explained effectively enough in recent works in literature. Of particular concern is the educational virtual reality environments developed because of this inefficient design process have pedagogical deficiencies. On the other hand, it has previously been observed that although there are many factors affecting individuals during training in virtual reality environments, it is seen that these points are often not taken into consideration during the design process. However, it is known that there is a need for extensive studies on the design of educational virtual reality environments. Based on these points, the purpose of this paper is to design an educational virtual reality environment in which many of the problems in the literature were handled holistically and to manage the development process.

Method: The approach to adopted for this study was Educational Design Research. Also a holistic model is utilized, VRID design model to the educational virtual reality environment development process.

Implications for Research and Practice: The importance and originality of this study are that it explores the design and development process of an educational virtual reality environment in a holistic manner. Educational Virtual Reality Campus can be an essential tool for researchers who want to work in this field. In future studies, different psychological (motivation, mood, anxiety, cyber-sickness, etc.), cognitive (cognitive load, problem-solving, cognitive problems, etc.), and physical (eye dryness, nausea, dizziness, etc.) elements can also be tested through this platform.

Keywords: Virtual Reality, Educational Campus, Internet of Things, Presence, EVRECA.

Eğitsel Sanal Gerçeklik Kampüsünün Tasarlanması ve Geliştirilmesi

Özet

Problem Durumu ve Amaç: Literatüre bakıldığında eğitsel sanal gerçeklik ortamlarının tasarlanması ve geliştirilmesi süreçlerinin yeterince etkili yürütülmediği ve açıklanmadığına dair araştırmaların olduğu görülmektedir. Yaşanan bu etkisiz sürecin sonucu olarak da geliştirilen eğitsel sanal gerçeklik ortamlarının pedagojik açıdan eksikliklere sahip olduğu belirlenmiştir. Öte yandan, sanal gerçeklik ortamlarında yapılan bir eğitim süresince bireyleri etkileyen çok sayıda etken olmasına rağmen tasarım sürecinde çoğu zaman bu noktalara dikkat edilmediği görülmektedir. Oysaki eğitsel sanal gerçeklik ortamlarının tasarımı üzerine kapsamlı çalışmalara ihtiyaç duyulduğu bilinmektedir. Bu noktalardan hareketle çalışmanın temel amacı, literatürde mevcut olan problemlerin birçoğunun bütüncül şekilde ele alındığı bir eğitsel sanal gerçeklik ortamını tasarlamak ve geliştirme sürecini yönetmek olmuştur. Bu temel amaç doğrultusunda sanal gerçeklik alanında ara yürütecek araştırmacılara tasarım ve geliştirme süreci ile ilgili bir kılavuz oluşturulması da hedeflenmiştir.

Yöntem: Çalışma Eğitsel Tasarım Araştırması metodolojisi altında yürütülmüştür. Eğitsel Sanal Gerçeklik Kampüsünün tasarlanması ve geliştirilmesi süreci ise VRID tasarım modeli ışığında gerçekleştirilmiştir. Model, tasarım ve geliştirme sürecini bütüncül bir yaklaşımla ele almakta gerek pedagojik gerekse teknik tüm basamakları içerisinde barındırmaktadır.

İleriye Dönük Araştırma ve Uygulama için Öneriler: Geliştirilen Eğitsel Sanal Gerçeklik Kampüsü bu alanda çalışmalar yapmak isteyen araştırmacılar için önemli bir araç olabilecek potansiyele sahiptir. Gelecek çalışmalarda sanal gerçeklik ortamında eğitim alan öğrenenleri etkileyebilecek farklı psikolojik (motivasyon, duygu durumları, anksiyete, siber hastalık vb.), bilişsel (bilişsel yük, problem çözme, bilişsel problemler vb.) ve fiziksel (göz kuruluğu, mide bulantısı, baş dönmesi vb.) unsurlar bu platform aracılığıyla test edilebilecektir. Tüm bunların yanı sıra platformun geliştirilmesi sürecinin adım adım aktarılıyor olmasının bu alanda çalışmalar yapacak araştırmacılara süreci nasıl yönetebilecekleri noktasında kılavuzluk yapabileceği düşünülmektedir.

Anahtar Kelimeler: Sanal Gerçeklik, Eğitsel Kampüs, Nesnelerin İnterneti, Bulunuşluk, EVRECA.

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Introduction

Virtual reality is defined as the ability of the user to perceive and interact with this environment sensually with the help of special technologies that she wears on her body, within a three-dimensional simulation of a real-world situation/environment created on the computer (Jost, Cobb, & Hämmerle, 2019; Neguţ, Matu, Sava, & David, 2016; Schwind, Leusmann, & Henze, 2019; Serin, 2020). As can be understood from the definition of virtual reality, these environments allow the opportunity to experience a different world by separating the people under its influence from the current world. For this reason, researchers have been interested in virtual reality technologies for a long time in today's world. In recent years, there has been a significant leap in the number of studies in the field of virtual reality (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020; Reski & Alissandrakis, 2020; Wang, He, & Chen, 2020). Researchers have benefited from virtual reality technologies in many different fields, such as health, engineering, psychology, education, entertainment, space science, geography, history, art, advertising, and marketing (Al Amri, Osman, & Al Musawi, 2020; Mercan, Doğan, Köseoğlu, & Tüzün, 2020; Schwind et al., 2019). Especially education researchers have shown great interest in these technologies because of the sense of immersion, interaction, and high level of presence that virtual reality offers to the participants. So much so that the researchers described virtual reality technologies as one of the most up-to-date technologies that have the potential to be actively used in education and training activities and conducted multi-dimensional research (Chuah, Chen, & Teh, 2011; Fowler, 2015; Kamińska et al., 2019; Kavanagh, Luxton-Reilly, Wuensche, & Plimmer, 2017). The main reasons for the increasing interest of education researchers in virtual reality technologies are shown as (i) increasing access to virtual reality technologies since the beginning of the 21st century (Servotte et al., 2020), (ii) advances in graphics technologies (Wang et al., 2020), and (iii) developments in taking innovative steps in education (Rogers, 2019).

When we look at the early stages of virtual reality studies in the field of education, researchers listed the positive effects of virtual reality as follows: (i) increasing learner motivation (Limniou, Roberts, & Papadopoulos, 2008; Ott & Tavella, 2009), (ii) providing a high level of interaction (Chittaro & Ranon, 2007), (iii) enabling learners to gain knowledge with less effort compared to the traditional learning environment (Chittaro & Ranon, 2007), (iv) making teaching processes more realistic and safe (Dalgarno, Hedberg, & Harper, 2002; Johnson & Levine, 2008), (v) supporting peer-to-peer collaborative learning (Huang, Rauch, & Liaw, 2010), (vi) improving learners' problem-solving (Leite, Svinicki, & Shi, 2010), and (vii) discovery of new concepts by providing rich teaching content (Huang et al., 2010). Similarly, studies examining the effects of virtual reality technologies on learners and learning have been carried out in recent studies. In many of these studies, it has been concluded that virtual reality increases academic achievement and offers learners a more realistic experience (Al Amri et al., 2020; Bench, Winter, & Francis, 2019; Gonzalez Lopez, Jimenez Betancourt, Ramirez Arredondo, Villalvazo Laureano, & Rodriguez Haro, 2019).

Although the use of virtual reality in educational environments is increasing day by day, it is known that there are gaps, deficiencies, and problems in research in this field ue to the nature of science. When we look at the issues in the literature in general, it is seen that the first striking issue is the lack of attention to the pedagogical aspects in the design process of educational virtual reality environments (Kamińska et al., 2019; Radianti et al., 2020). However, it is noteworthy that the design processes are not explained comprehensively, which causes the repeatability levels of the studies to remain at a deficient level (Kamińska et al., 2019; Radianti et al., 2020). These fundamental problems that arise during the development process cause the developed educational virtual reality environments to have significant deficiencies in terms of learning theories, learner gains, and correct execution of the measurement and evaluation processes of the training (Chavez & Bayona, 2018; Jensen & Konradsen, 2018; Queiroz, Nascimento, Tori, & da Silva Leme, 2019; Radianti et al., 2020). However, although many factors can affect learners in an educational process in virtual reality environments (feeling of presence, cyber-sickness, cognitive load, physical health problems, graphic quality, virtual reality technologies, etc.), there is generally only one of these elements is focused on. However, it has been expressed by many researchers that there is a need for detailed studies that examine different factors affecting user performance at the same time (Çağlar, 2019; Feng, González, Amor, Lovreglio, & Cabrera-Guerrero, 2018; Suh & Prophet, 2018). Similarly, many educational researchers working in the field of educational virtual reality stated that there is a need for comprehensive studies on the learning experiences of individuals with virtual reality technologies (Aebersold, Rasmussen, & Mulrenin, 2020; Baceviciute, Mottelson, Terkildsen, & Makransky, 2020; Gonzalez Lopez et al., 2019). Researchers have defined the most significant deficiency at this point as the insufficient number of training in which learners can use not only their cognitive skills but also their psycho-motor skills in the virtual reality environment (Chavez & Bayona, 2018; Queiroz et al., 2019; Radianti et al., 2020).

From a general perspective, it is possible to say that researchers aim to ensure that individuals benefit from this technology at the highest level by conducting studies on different subjects in educational virtual reality environments. On the other hand, it is seen that there are problems in educational virtual reality environments developed as explained above and learning activities performed in these environments. The main purpose of this study, which was carried out from the specified points, is to design an educational virtual reality environment in which many of the problems existing in the literature are handled holistically and to manage the development process. In line with this main purpose, it is also aimed to create a guide about the design and development process for researchers who will carry out studies in virtual reality.

Method

The approach to adopted for this study was Educational Design Research (EDR). Analysis, design and evaluation phases constitute the three basic steps of the generic model for conducting Educational Design Research. (McKenney & Reeves, 2012). The generic model for the EDR is shown in Figure 1.

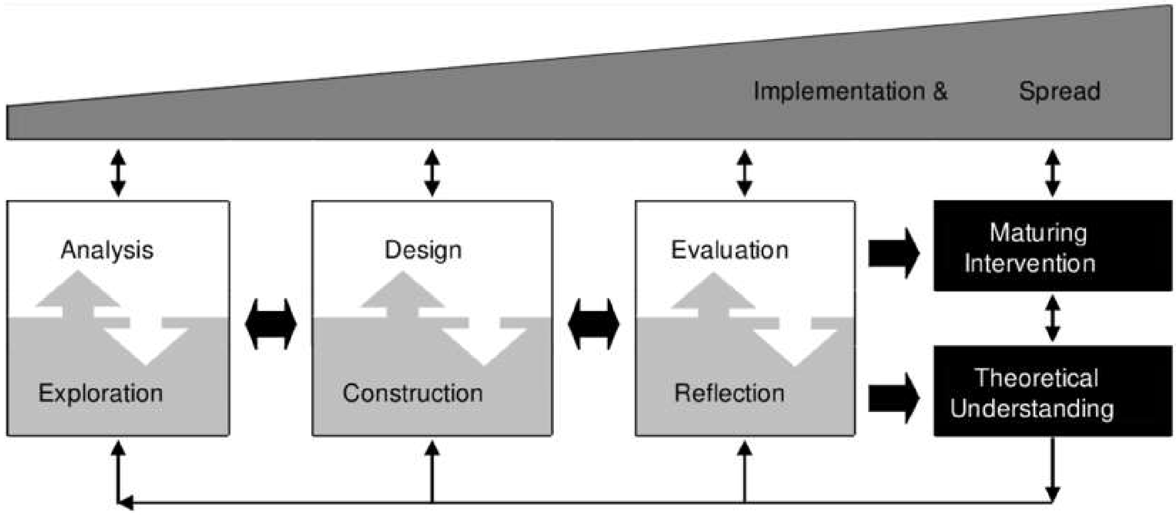


Figure 1. Generic model for conducting educational design research (McKenney & Reeves, 2012)

To design and develop an educational virtual reality environment in which the problems in the literature are handled holistically, it was decided to determine a design model first. For this reason, the design models developed for educational virtual reality environments were examined after a comprehensive literature analysis. In model selection, attention was paid to the educational, design, and technical steps of the relevant model (Geris & Özdener, 2020), and it was decided to use the VRID design model in the study. The VRID design model developed by (Chen, 2009) has a structure consisting of four main steps and twelve sub-items, including learning theories and strategies. The model is shown in Figure 2.

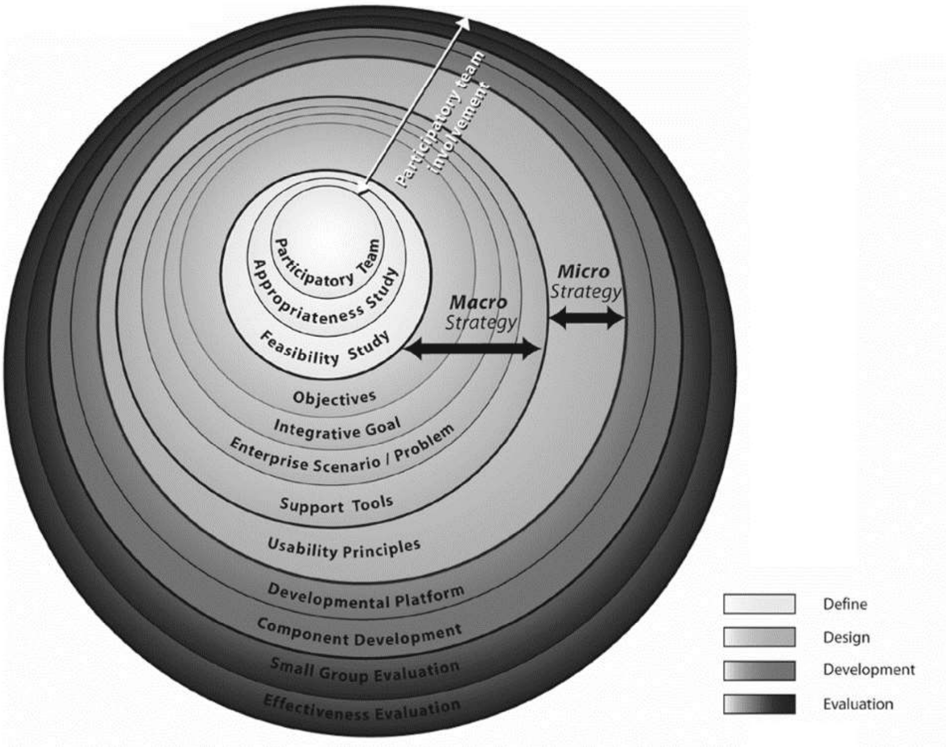


Figure 2. VRID instructional design and development model (Chen, 2009)

Designing and Development of EVRECA

This section explains in detail how the Educational Virtual Reality Campus – EVRECA platform, which was developed within the scope of the study, was designed and developed under the steps of the VRID design model. In accordance with the model in Figure 1, firstly, the Define step is discussed.

Define

In the define section, firstly the participants who will take part in the design and development of the platform were determined. Then the appropriateness studies of the training planned to be given in the virtual reality environment were carried out with the participant group. Finally, the participant group has also completed the feasibility studies.

Participatory team. Within the scope of this study, which deals with the process of designing a virtual reality-based educational environment, firstly, the participant group of the study was determined in the light of the features given in the model and is shown in Table 1.

Table 1. Participatory team members

No	Role	Working Area
E01	Coordinator, Instructional Strategies Specialist, Interface Designer, Programming Specialist	Lecturer in the field of Computer Education and Instructional Technologies
E02	Field Specialist, Instructional Strategies Specialist	Lecturer in the field of Computer Education and Instructional Technologies
E03	3D Artist	3D Artist Working in a Game Development Company with Five Years of Experience
E04	Game Developer	Programmer Working in a Game Development Company with Seven Years of Experience
E05	Field Specialists	Lecturers in the field of Computer Education and Instructional Technologies
E06	Target Group	Higher Education Students in the Scope of the Study Group

Appropriateness studies. Within the scope of the appropriateness studies of the design process, the coordinator, field specialists, instructional designers, interface designers, and technical experts in the participant group came together and evaluated. In this context, following the design model, the suitability of the three-dimensional depiction of the items used in the Internet of Things training, which was determined as the subject of education within the scope of this study, was analyzed. Then, it was examined whether the training content could be simulated in the virtual reality environment. Finally, analyses were carried out because the evaluation studies of the educational content to be integrated into the virtual reality environment can also be controlled in the virtual reality environment. At the end of all these steps, it was decided that the subject of the Internet of Things is suitable for training that can be given in a virtual reality environment.

Feasibility studies. Within the scope of feasibility studies, first, the hardware elements required in the development process were determined. The study determined virtual reality glass equipment and a computer with a high-level graphics processor as mandatory hardware items. In addition to this, it has been determined that a camera that allows obtaining high-resolution photographs of the items to be used for modeling will also be needed. At the same time, within the scope of the study, it was determined that there was a need for high-speed internet connection, a platform for the design, block-based visual programming software, three-dimensional modeling software for modeling, software for programming studies during the development of the environment, and software that would provide virtual reality integration. At this point, when the possibilities available to the participant group were evaluated, it was determined that two surrounding virtual reality glasses, computers, necessary software, and high-speed internet connection were available. It has been decided to take measures to provide financial resources by designing the study despite the negative situations that may occur during the process.

Design

Within the scope of the design step, the objectives of the training and applications to be given in the study, the integrative goal of the virtual reality environment and education, the stage design features of the platform, support tools, and usability principles were determined and explained under sub-headings.

Objectives. The practices that learners will do in the education to be given in the virtual reality environment, the learning activities, and the studies on their evaluation constitute the objectives of the education and the general learning framework that is aimed to be achieved as a result of these objectives constitutes the integrative goal of the study. In training held in the educational virtual reality campus developed within the scope of the research, the subject of internet of objects education was discussed. In the process of determining the achievements of the subject, opinions were taken from five different field experts, and because of these opinions, the final form of the objectives to be obtained from education was formed. The objectives of education are expressed in 50 items in total.

Integrative goal. The integrative goal, which is expected to deliver the learning outcomes determined within the scope of the training, is "learning the concept of the internet of things, recognizing physical circuit elements, having project development knowledge using sensors and physical circuit elements, performing physical circuit installation in a real-life laboratory environment, and programming the developed projects with block-based coding" has been determined. The main reasons for deciding this goal are to convey to the learners why the projects that can be realized with the Internet of Things are necessary, how the relationship between objects and people develops and can develop, and how the processes of developing IoT projects work. On the way to reach the integrative goal determined within the scope of education, learners benefit from the objectives. At the point of going the parts in the integrative goal and filling the gaps between the parts, the objectives' experiences are effective.

Enterprise scenario. In the content of the projects and training prepared for the education of the Internet of Things, a path from simple to complex was followed to create the context of the problem. A scenario was considered while creating the context for each project. At this point, the scenarios have been prepared on protecting and activating a sustainable environment. In the projects included in the training content, attention was paid to creating effective and fast project models that could be made for a sustainable environment by those who received the Internet of Things training. At the same time, the context of the training in the general framework and the context of each project are arranged to be consistent. In this way, it is aimed for the learners to understand the general problem and to associate the specific problem of each project with the educational content. In addition, the stage design was positioned on an island, and attention was paid to ensure that the main idea of education and the current environment were compatible with each other. To ensure that learners do not forget that they are in the educational environment within the virtual reality platform, the stations are identified with school and project names.

To ensure that the gains in stage design can be fully achieved, the learners in the information school, the education department are provided to perceive all the content with their different senses. At the same time, the interaction opportunities allow the participants to adapt to the scene and the environment entirely. In the training and application sections of the projects, the chance to interact is constantly provided to the participants, ensuring that the learners always take an active role in the application. At this point, attention was paid to arranging the elements used in the stage design to attract the participants. At the same time, with the room systems developed inside each other, the learners in each project could go back to the point they wanted or move forward without leaving the current scenario.

In addition to these features, gamification elements were also used to increase the participants' motivation during the project development and object collection activities. It was ensured that the participants gained 100 points for each correct choice in the object collection activity and lost 50 points for the wrong decisions. In addition, if the participants completed the projects, they were allowed to earn 500 points from the first project, 1000 from the second project, and 2000 from the third project.

Support tools. In this study, in which Guided Discovery Learning was used as a supportive teaching strategy, many different items such as text-based information screens, audio information, visual guidance tools, three-dimensional models, and educational videos were used to help learners build knowledge in the developed virtual reality environment. As the first step of the Guided Discovery Learning strategy, no unnecessary information or visualization was presented to the learners in the environment within the scope of the process constraints. Attention was paid to ensure that the learning process of the learners consisted of only the educational content. In this context, all items in the environment have been developed from or under the educational content. In addition, an information and control menu has been created for learners to follow their progress. With these arrangements made within the scope of the performance dashboard, learners were able to see which stages of the training they had completed, how many points they could collect from the stages they finished, and which stages were waiting for them (Figure 3a). At the same time, the participants were also allowed to control information such as sound level and controller configuration in the training environment.

a. Performance dashboard b. Scaffolds

Figure 3. Support tools

During the warnings step of the guided discovery learning strategy, audio and visual stimuli were given to the participants in stages such as training activities, physical circuit installation activities, and correct arrangement of code blocks. These warnings were shown to participants for informational or reminder purposes only and did not directly relate to their duties or training activities. However, when considering the prompts, the participants were given directions about the activities to do. As stated in the process constraints, the projects are arranged from simple to complex. Similarly, heuristics are set from simple to complex. For example, in the first project activity, the participants received visual and text-based stimuli about the task steps. They received only text-based stimuli in the second project, and in the third project, they received only audio stimuli. A three-dimensional model of the projects they will realize within the scope of scaffolds, which is the last strategy step that will help the learning activity of the participants, is shown. Although these models do not have clear lines, they are arranged to indicate the general scheme to the learners (Figure 3b).

Usability principles. Another point to focus on after completing the design elements in line with macro strategies is micro strategies. The primary purpose of this section, also called usability studies, is to carry out studies for the most effective presentation of learning content. At this stage, the first point to be considered is to avoid items that increase learners' cognitive load. Learners' attention in the virtual reality environment should be directed to the educational content as much as possible. The learner should not be distracted by objects, designs, or sounds other than the educational content (Chen, 2009). Within the scope of the study, attention was paid to these issues during the development of the environment, care was taken to ensure that they could interact with the items other than the training content at the minimum level, and the orientations were made under the training content. In addition, the video content - true - false warning sounds and the sounds other than the platform background music in training were left to the control of the students. It is left to the student's choice whether to listen to the audio content they want or not. In addition, a volume control option has been added to the menu section so that learners can adjust their audio levels whenever they want.

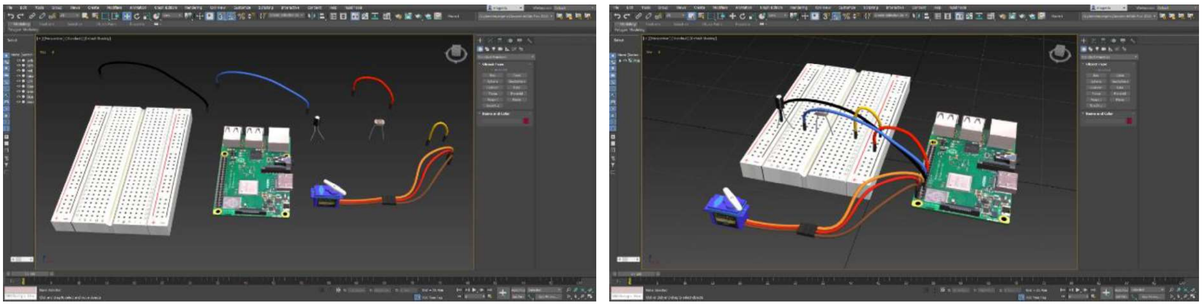
Other points to be considered within the scope of usability studies are the level of interaction that learners have with objects, contents, and the environment. At this point, within the scope of the study, it was ensured that the learners could only interact with the objects suitable for the educational content, other visual materials were designed not to allow interaction, attention was paid not to create distracting elements from the environment, and the educational contents were tried to be given clearly without including too much information for the purpose. At the same time, precautions were taken in the natural practice environment so that learners are not distracted and physically challenged during the training in the developed learning environment.

Development

In the development stage of the VRID design model, first, the platform on which the virtual reality application will be developed should be decided according to the model. Then the development process of the components should be directed. The steps taken at this point are explained in the sub-headings.

Developmental platform. Different alternatives were evaluated in terms of which platform the educational virtual reality environment developed within the scope of this study will be designed. Platforms considered were Sansar, developed by Linden Lab, Unreal Engine, developed by Epic Games, and Unity. Within the scope of the research, the experts in the participant group examined the three platforms in detail and made evaluations. These evaluations were carried out under the titles of library support, three-dimensional model integration, usability, programming support, and auxiliary resource possibilities of the platform. As a result of the examinations, it was decided to use Unity as the developmental platform. The development process of the EVRECA platform started with the Unity 2018.3.11f1 version and was completed with this version.

Component development. After the development platform was decided, the development of the elements to be used in the educational environment was started. In this context, first, the authentic images of the physical circuit elements and sensors to be used in training were obtained from different angles with a high-resolution camera and transmitted to the 3D Artist. The expert started to work with the visuals of the objects to be modeled and created three-dimensional models of the objects in the 3ds Max 2017 program (Figure 4a). The models were then transferred to Unity.



a. Models of physical circuit elements　　　b. Completed project model

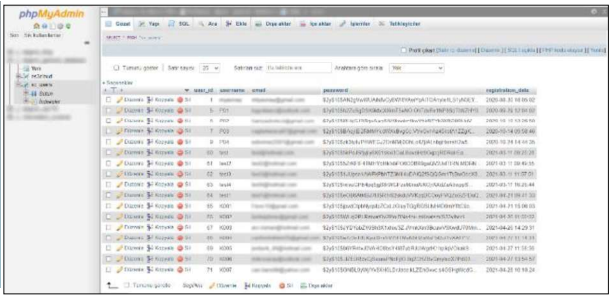
Figure 4. Three-dimensional modeling images

Elements such as desks, cabinets, screens, buttons, floors, etc., of the educational buildings to be included in the environment were obtained free of charge from the Unity Library and integrated into the platform. The projects' completed models in the platform's educational content were also obtained by establishing physical circuits in real life and transforming their visuals into three-dimensional models through the 3ds Max 2017 program (Figure 4b). The virtual avatar character, which was decided to be used in the platform after the pilot application and given directions, was obtained through the Unity Library and integrated into the system.

In addition to visual components, text-based components and two-dimensional visual tools were prepared by the researcher with Adobe Photoshop 2020, a 2D design program. The composed images were integrated into Unity and used on the platform. In addition, audio components are also used in the developed virtual reality platform. Sounds such as the background sound of the platform, true - false warning sounds, physical circuit installation effect is obtained from online platforms with free license rights. In addition, audio stimuli such as informative texts and warning contents were voiced by an expert. All these contents have been added to the Unity Library and integrated into their place on the platform.

In addition to the design content on the platform, a database has also been developed to store the application data of the users. A user registration screen has been created for each user who will experience the EVRECA platform, and then a start screen has been designed that will allow them to log in to the system (Figure 5a). Information such as the total time spent by the users in the platform after logging in to the environment, the last session times if they log in more than once, the time to complete the practice section, the time they spent in the knowledge school, the time to complete the projects were instantly integrated into the database (Figure 5b). In addition, the points obtained by the participants and the point of the last activity in case of exiting were recorded in the database. Thus, in case of an error or interruption in the implementation process, all information of the participants was protected, and they could continue the training process from where they left off.

a. EVRECA login screen



b. Database

Figure 5. Login and database screens

The steps taken during the development of the Educational Virtual Reality Campus – EVRECA platform are explained in detail in this section. The experts' opinions in the participant group were taken at each stage, and evaluations were made. After the development phase, multiple experts' views about the platform were taken, and improvement studies were carried out.

Conclusion and Recommendations

The Educational Virtual Reality Campus, which was designed and developed within the scope of this study, is expected to contribute to the studies to be carried out in this field, as it provides both psychomotor and cognitive training. With the training that can be given on the Educational Virtual Reality Campus, an opportunity will be created for learners to receive training that can be dangerous in physical environments or that cannot be carried out due to financial reasons or that are difficult to repeat. At the same time, different activities and assessment methods will be offered to the participants with the platform, which allows training in which psycho-motor skills are used in virtual reality environments. Thus, the training processes carried out in virtual reality environments will be followed more effectively.

The developed Educational Virtual Reality Campus will also be an essential tool for researchers working in this field. In future studies, different psychological (motivation, emotional states, anxiety, cyber-sickness, etc.), cognitive (cognitive load, problem-solving, cognitive problems, etc.), and physical (dry eyes, nausea, dizziness, etc.) elements can also be tested through this platform. In this context, and within the scope of the evaluation stage, which is the last step of the VRID design model, the efforts to present the learning activity to the target audience continue the platform developed. In the study, both the platform's effect on the participants' academic achievement and the impact of cognitive, physical, and psychological aspects are examined. The results will be presented to the literature as a scientific study. In addition to all these, it is thought that the step-by-step transfer of the platform's development process can guide researchers who will work in this field on how to manage the process.

References

Aebersold, M., Rasmussen, J., & Mulrenin, T. (2020). Virtual Everest: Immersive Virtual Reality Can Improve the Simulation Experience. *Clinical Simulation in Nursing, 38*, 1-4.

Al Amri, A. Y., Osman, M. E., & Al Musawi, A. S. (2020). The Effectiveness of a 3D-Virtual Reality Learning Environment (3D-VRLE) on the Omani Eighth Grade Students' Achievement and Motivation towards Physics Learning. *International Journal of Emerging Technologies in Learning (iJET), 15*(05), 4-16.

Baceviciute, S., Mottelson, A., Terkildsen, T., & Makransky, G. (2020). *Investigating Representation of Text and Audio in Educational VR using Learning Outcomes and EEG.* Paper presented at the Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems.

Bench, S., Winter, C., & Francis, G. (2019). Use of a Virtual Reality Device for Basic Life Support Training: Prototype Testing and an Exploration of Users' Views and Experience. *Simulation in Healthcare, 14*(5), 287-292.

Chavez, B., & Bayona, S. (2018). *Virtual reality in the learning process.* Paper presented at the World Conference on Information Systems and Technologies.

Chen, C. J. (2009). Theoretical Bases for Using Virtual Reality in Education. *Themes in Science and Technology Education*(Special Issue), 71-90.

Chittaro, L., & Ranon, R. (2007). Web3D technologies in learning, education and training: Motivations, issues, opportunities. *Computers & Education, 49*(1), 3-18.

Chuah, K.-M., Chen, C.-J., & Teh, C.-S. (2011). Designing a Desktop Virtual Reality-Based Learning Environment with Emotional Consideration. *Research & Practice in Technology Enhanced Learning, 6*(1).

Çağlar, C. (2019). *Yabancı Dil Öğretiminde Seyahat İngilizcesi İçin Sanal Gerçeklik Uygulamasının Geliştirilmesi.* (Yüksek Lisans Tezi). İstanbul Üniversitesi, İstanbul.

Dalgarno, B., Hedberg, J., & Harper, B. (2002). The contribution of 3D environments to conceptual understanding.

Feng, Z., González, V. A., Amor, R., Lovreglio, R., & Cabrera-Guerrero, G. (2018). Immersive virtual reality serious games for evacuation training and research: A systematic literature review. *Computers & Education, 127*, 252-266.

Fowler, C. (2015). Virtual reality and learning: Where is the pedagogy? *British Journal of Educational Technology, 46*(2), 412-422.

Geris, A., & Özdener, N. (2020). Design Models for Developing Educational Virtual Reality Environments: A Systematic Review. *Virtual and Augmented Reality in Education, Art, and Museums*, 1-22.

Gonzalez Lopez, J. M., Jimenez Betancourt, R. O., Ramirez Arredondo, J. M., Villalvazo Laureano, E., & Rodriguez Haro, F. (2019). Incorporating virtual reality into the teaching and training of Grid-Tie photovoltaic power plants design. *Applied Sciences, 9*(21), 4480.

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.

Jensen, L., & Konradsen, F. (2018). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies, 23*(4), 1515-1529.

Johnson, L. F., & Levine, A. H. (2008). Virtual worlds: Inherently immersive, highly social learning spaces. *Theory Into Practice, 47*(2), 161-170.

Jost, P., Cobb, S., & Hämmerle, I. (2019). Reality-based interaction affecting mental workload in virtual reality mental arithmetic training. *Behaviour & Information Technology*, 1-17.

Kamińska, D., Sapiński, T., Wiak, S., Tikk, T., Haamer, R. E., Avots, E., . . . Anbarjafari, G. (2019). Virtual Reality and Its Applications in Education: Survey. *Information, 10*(10), 318.

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A systematic review of Virtual Reality in education. *Themes in Science and Technology Education, 10*(2), 85-119.

Leite, W. L., Svinicki, M., & Shi, Y. (2010). Attempted validation of the scores of the VARK: Learning styles inventory with multitrait–multimethod confirmatory factor analysis models. *Educational and psychological measurement, 70*(2), 323-339.

Limniou, M., Roberts, D., & Papadopoulos, N. (2008). Full immersive virtual environment CAVE TM in chemistry education. *Computers & Education, 51*(2), 584-593.

McKenney, S., & Reeves, T. C. (2012). *Conducting Educational Design Research*: Routledge.

Mercan, G., Doğan, D., Köseoğlu, P., & Tüzün, H. (2020). Design Process of Three-Dimensional Multi-User Virtual Environments (3D MUVEs) for Teaching Tree Species. In *Enriching Teaching and Learning Environments With Contemporary Technologies* (pp. 117-137): IGI Global.

Neguț, A., Matu, S.-A., Sava, F. A., & David, D. (2016). Task difficulty of virtual reality-based assessment tools compared to classical paper-and-pencil or computerized measures: A meta-analytic approach. *Computers in Human Behavior, 54*, 414-424.

Ott, M., & Tavella, M. (2009). A contribution to the understanding of what makes young students genuinely engaged in computer-based learning tasks. *Procedia-Social and Behavioral Sciences, 1*(1), 184-188.

Queiroz, A. C. M., Nascimento, A. M., Tori, R., & da Silva Leme, M. I. (2019). *Immersive virtual environments and learning assessments.* Paper presented at the International Conference on Immersive Learning.

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education, 147*, 103778.

Reski, N., & Alissandrakis, A. (2020). Open data exploration in virtual reality: a comparative study of input technology. *Virtual Reality, 24*(1), 1-22.

Rogers, S. (2019). Virtual Reality: The Learning Aid Of The 21st Century. *Forbes*.

Schwind, V., Leusmann, J., & Henze, N. (2019). Understanding Visual-Haptic Integration of Avatar Hands Using a Fitts' Law Task in Virtual Reality. In *Proceedings of Mensch und Computer 2019* (pp. 211-222).

Serin, H. (2020). Virtual Reality in Education from the Perspective of Teachers. *Amazonia Investiga, 9*(26), 291-303.

Servotte, J.-C., Goosse, M., Campbell, S. H., Dardenne, N., Pilote, B., Simoneau, I. L., . . . Ghuysen, A. (2020). Virtual Reality Experience: Immersion, Sense of Presence, and Cybersickness. *Clinical Simulation in Nursing, 38*, 35-43.

Suh, A., & Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human Behavior, 86*, 77-90.

Wang, Z., He, R., & Chen, K. (2020). Thermal comfort and virtual reality headsets. *Applied Ergonomics, 85*, 103066.