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DEVELOPMENT ARTICLE

Design, development, and evaluation of educational virtual reality environment: EVRECA

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Abstract

Numerous studies have been carried out in recent years on the use of virtual reality (VR) technologies and environments in education. On the other hand, many researchers have drawn attention to the inadequacy of studies that deal with the education process in virtual reality environments from a broad perspective. In this research, the process of designing, developing, and testing an educational virtual reality environment in the light of a design model that includes pedagogical, design, and technical steps have been experienced and reported with a holistic perspective. The study was carried out in a two meso cycle structure based on the educational design research methodology. In the scope of research, the educational virtual reality campus platform has been developed to provide a skill-based educational environment for learners. The Internet of Things training process in the platform was held in a single session with each participant. At the end of the practices, it has been seen that the training carried out on the platform can provide learning at both cognitive and skill levels; the knowledge learned in the virtual reality environment can be transferred to real life and has a lasting effect. Furthermore, it was determined that there was a reverse relationship between the participants' sense of presence and their cognitive load, and there was a positive relationship between the participants' sense of presence and their pleasure and arousal levels. It has been concluded that technical data such as frames per second, latency, draw call, and polygon count provided by the platform can have a remarkable effect on the VR experience.

Keywords EVRECA · Virtual reality · Skill-based learning · Sense of presence · FPS

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Introduction

Historically, virtual reality (VR) technologies have existed for roughly sixty years, but their usage and prevalence, particularly over the past twenty-five years, have seen significant advancement (Helgert et al., 2022; Reski & Alissandrakis, 2020; Wang et al., 2020). Alongside this progress, the use of VR in educational settings has also seen a marked increase. As a result, researchers have conducted numerous studies on educational VR environments and sought to maximize their potential (Bawa & Bawa, 2023; Cai et al., 2023). Despite these developments and valuable research, however, it has been noted that various issues arise within this field due to its inherent nature.

From the most general perspective, it is seen that the processes of designing and developing educational VR environments are not carried out and explained effectively enough. Wang et al. (2018) determined that one of the most striking problems experienced in studies in engineering education is that learning theories are not considered during the development of VR environments. Similarly, Radianti et al. (2020), who analysed the studies in VR in detail, emphasized that there are major deficiencies in the points of learning methods and theories that can guide learning outcomes in their studies. As a result of these deficiencies, it has been seen that the evaluations and methods on learning outcomes are insufficient (Chavez & Bayona, 2018; Jensen & Konradsen, 2018; Radianti et al., 2020). Furthermore, when the educational content given in VR environments was examined, it was determined that the researchers did not focus enough on the subjects in higher education (Queiroz et al., 2019; Radianti et al., 2020). On the other hand, it has been observed that many studies conducted in VR environments focus on teaching procedures or acting in defined areas. At this point, the researchers drew particular attention to the scarcity of VR studies in which psychomotor skills could be used or developed based on experience (Radianti et al., 2020; Stavroulia et al., 2019).

During the training held in VR environments, research was carried out not only on the learning status of individuals but also on other factors affecting them. As a result of these studies, it has been seen that VR technologies can affect individuals' physical (nausea, dry eyes, etc.), cognitive (learning, cognitive load, etc.), and psychological (presence, motivation, etc.) aspects (Armougum et al., 2019; Roettl & Terlutter, 2018; Schwind et al., 2019a; Xie et al., 2023). However, although it has been determined that many factors affect the participants in VR environments, it is noteworthy that the studies generally focus on a single point. However, it is stated by many researchers that there is a need for studies that examine different factors affecting users at the same time (Çağlar, 2019; Feng et al., 2018; Suh & Prophet, 2018).

Similar to the deficiencies encountered during the evaluation of the learning outcomes in training conducted in VR environments, it has been observed that there are problems in the evaluation process of the VR environment used (Queiroz et al., 2019). For example, Suh and Prophet (2018) specifically stated that there is not enough work on testing the performance of VR environments. In addition, Radianti et al. (2020) said that although some studies have conducted usability tests of VR environments, only usability analyses will be insufficient to determine the effectiveness of these environments. In the light of all these mentioned results, it has been seen that many educational researchers have stated that there is a need for comprehensive studies that will investigate the effect of VR on individuals and the efficiency of virtual reality environments (Aebersold et al., 2020; Baceviciute et al., 2020; Gonzalez Lopez et al., 2019).

In the realm of academic literature, the comprehensive exploration of design and development processes concerning educational virtual reality environments remains a notably under-addressed and under-discussed area. Although there are myriad factors affecting individuals within VR training environments, research endeavours have often been confined to isolated facets. While these individual studies have undoubtedly contributed valuable insights, there persists a conspicuous gap in the literature relating to the holistic conception, creation, and evaluation of educational VR environments. Furthermore, a recognized exigency exists for more in-depth investigations that concurrently scrutinize the diverse determinants influencing user performance, encompassing aspects such as physical and psychological ramifications, environmental technical specifications, and beyond.

Conversely, educators, practitioners, and policymakers on a global scale are displaying significant interest in comprehending the effectiveness and far-reaching influence of virtual reality (VR) in the realm of teaching and learning. This research endeavour, which centers on the intricate processes of designing, developing, and critically evaluating educational VR environments, alongside the multifaceted determinants that exert influence on user performance, addresses a fundamental void in the ongoing international discourse surrounding educational technology. Through a scrupulous exploration of cognitive and psychomotor proficiencies, technical intricacies of the environment, and the cognitive and psychological dimensions, this study delivers an all-encompassing perspective to VR-based educational practices on a global canvas.

Aim

This study was motivated by the desire to investigate whether an educational virtual reality environment designed and developed with a holistic perspective and tested for technical efficiency could enable participants to enhance their academic success and transfer their knowledge to real-world situations through experiential learning, while also supporting their cognitive and psychological aspects. To this end, this research aimed to experience and document the process of designing, developing, and testing an educational virtual reality environment based on a model that includes pedagogical, design, and technical steps with a holistic perspective. To achieve this goal, a platform called the educational virtual reality campus (EVRECA) was developed, which offers learners a skills-based education opportunity in a study conducted using the educational design research (EDR) methodology in a two-meso cycle structure. During the learning activities on the EVRECA platform, the following questions were addressed.

1. How does the platform affect the academic achievement levels of the participants?
2. What is the relationship between the academic achievement levels of the participants and the transfer of the knowledge they learned to real life?
3. What are the cognitive and psychological effects of the platform on the participants, and what is the relationship between them?
4. What is the technical efficiency of the platform?

Background of the study

Learning in virtual reality environments

When we look at the literature in general, it is seen that many researchers had examined the effects of these technologies on the learning experience since the 2000s, when VR technologies began to become widespread. For example, Appelman (2005) determined that problems such as mobility, interaction, and spatial boundaries that learners can experience in three-dimensional environments can be overcome in VR environments. Ramasundaram et al. (2005) similarly stated in the literature the two main limitations of the physical world; He said that (1) the inability to have the opportunity to experience the real environment due to distance, time, price, or security reasons, and (2) the difficulty of observing the unlimited possibilities that exist in the real environment can be overcome thanks to VR environments. In addition, Monahan et al. (2008) determined that students who receive education in VR environments can feel the presence of their classmates and teachers better, even though they are not physically in the same environment.

In addition to the benefits that VR environments offer to individuals, more extensive research has also shown that VR technologies can affect learning processes from different aspects. For example, Piovesan et al. (2012) determined that the objects that students interact with within VR environments create a sense of realism in the participants, ensuring that the learned information is more permanent. Furthermore, in the research conducted by Topuz (2018), it was concluded that VR applications effectively teach subjects that are difficult to see with the naked eye or that cannot be examined comprehensively and that they are also successful in establishing a part-whole relationship with the participants. On the other hand, Frazier et al. (2021) stated that VR is a powerful tool that can be used to improve students' language learning experiences. However, it has been noted that many studies in the literature ignore various issues that arise during and after learning experiences. For example, Radianti et al. (2020) emphasized that there are significant gaps in learning methods and theories that can guide learning outcomes in their research. As a result of these gaps, it has been found that evaluations and methods for measuring learning outcomes are insufficient (Chavez & Bayona, 2018; Jensen & Konradsen, 2018; Radianti et al., 2020).

In recent studies, researchers have focused especially on the level of learned knowledge. In their research, Gonzalez Lopez et al. (2019) found that students who receive education in the VR environment are more successful academically. Al Amri et al. (2020), who conducted a study on the physics course with eighth-grade secondary students, found that the group that received education in the VR environment achieved more successful academic results. Kalkan (2020), who has worked on psychomotor skills and academic success, has shown that VR can be used to develop basic technical skills in table tennis. In summary, it has been determined that the educational use of VR technologies and the training carried out in VR environments positively affect learners. At the same time, many studies have revealed that with the training to be given in VR environments, contributions can be made to the learners at both the knowledge level and the skill level. Despite all this, upon examining the educational content provided in virtual reality environments, it has been determined that researchers do not adequately focus on subjects in higher education. Additionally, the researchers highlighted the lack of VR studies that utilize or develop psychomotor skills based on experience (Radianti et al., 2020; Stavroulia et al., 2019). Despite recognizing that many factors impact participants in VR environments, it is noteworthy that studies often focus on a single factor. Researchers have stated that there is a need for studies that examine the various factors (such as presence, cognitive load, equipment, technical specifications of the environment, etc.) that affect users in VR simultaneously (Çağlar, 2019; Feng et al., 2018; Suh & Prophet, 2018) .

Sense of presence in virtual reality environments

The main point of experiencing VR environments is to use immersive VR technologies as it is known. In reality, researchers have observed that various factors affect participants during their experience of VR environments and learning activities. From this point of view, researchers have also carried out studies examining the effects of VR and wearable technologies on both learning and individuals. Sense of presence (SoP) is at the forefront of the issues identified by researchers and studied for a long time. The SoP has found that an effective VR environment can provide a high presence and positively affect learning (Cho et al., 2015; Roettl & Terlutter, 2018). In addition to this situation, it has been determined that the SoP is related to more than one subject. For example, some studies have reported that the SoP is affected by sensory factors such as smell, touch, and hearing (García-Valle et al., 2017; Kern & Ellermeier, 2020; Narciso et al., 2020). On the other hand, it was also stated that the SoP affected the learning activity, cognitive load levels, or psychological aspects (anxiety, fear, motivation, etc.) experienced by the participants (Gromer et al., 2019; Shimizu et al., 2019). Even if the sense of being exists considered on its own, it can be seen that many factors affect the participants' learning experiences in VR environments.

Cognitive load in virtual reality environments

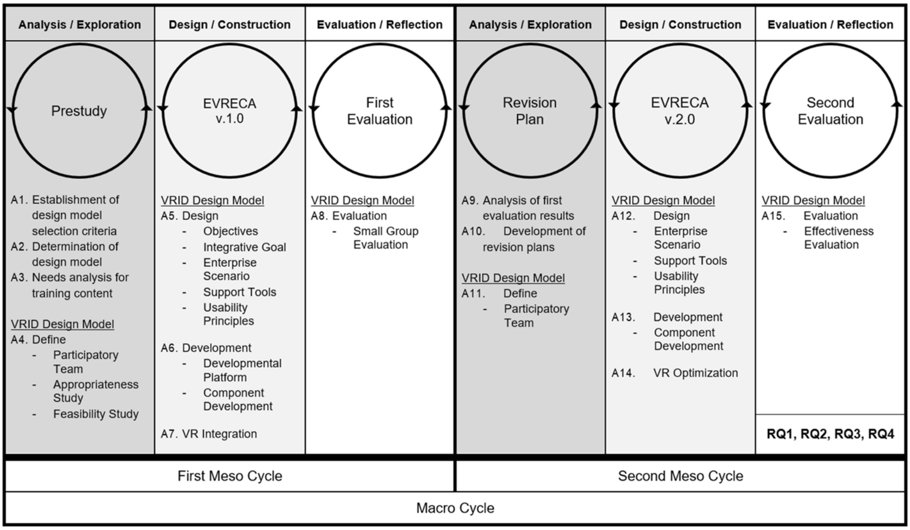
In recent studies, it has been observed that individuals may experience physical and psychological problems such as stress, anxiety, nausea, dizziness, motion sickness, cognitive load and dry eyes while experiencing VR environments (Checa & Bustillo, 2020; Liu et al., 2020). It has been determined that these problems affect the participants cognitively as well as physically and psychologically. It is also known that due to physical and psychological issues, participants may not be able to start their learning experiences at all, may stop the activity, or may not have a sufficiently effective learning process even if they complete the training (Liu et al., 2020; Turnbull et al., 2019). As a result of this situation, it has been observed that the cognitive load levels of the participants during their experience of the VR environment can affect learning negatively (Hite et al., 2019; Jost et al., 2019). However, some studies in the literature report that VR technologies do not increase the level of cognitive load experienced by individuals in the learning environment (Jost et al., 2019; Topuz, 2018). At this point, researchers stated that the scope of VR studies should be expanded, and different factors that may affect cognitive load should be examined simultaneously (Armougum et al., 2019; Hite et al., 2019).

Technical features of virtual reality environments

Another issue that affects individuals in virtual reality environments is the VR environments themselves, which the participants experience and feel like they are there. Some researchers working in this field have reported that low-quality designed VR environments negatively affect the VR experiences of the participants (Tran et al., 2019; Zou et al., 2018). On the other hand, Luo et al. (2021) emphasized that although the quality of VR glasses has increased, the quality of the developed environments is still insufficient, and technical issues are not paid attention to. Furthermore, Zhang (2020) found that users may encounter problems such as dizziness, headache, nausea, and disorientation in VR environment experiences below 50 frame per second (FPS). Fu et al. (2021), on the other hand, stated that when the polygon count values in the VR environment are reduced by 30–40%, the stage performance increases, and the discomfort experienced by the participants' decreases. On the other hand, it is noteworthy that the number of studies examining the technical aspects of educational VR environments is scarce.

Method

The educational design research (EDR) methodology was taken as a research model in this study. EDR methodology with its circular and flexible structure; It is preferred to carry out research on educational technology-specific tools, to carry out studies on the solutions of educational problems and to research the use of new teaching tools (Burkhardt, 2009; Joe, 2020; McKenney & Reeves, 2014; Reeves, 2011; Stemberger & Cencic, 2014). As a matter of fact, EDR methodology was preferred in this study, as it was aimed to develop and test an educational virtual reality environment that offers a practice-based education process to learners. Within the scope of the research, the model named "Generic model for conducting educational design research" was used by McKenney and Reeves (2012) under three main headings: analysis/exploration, design/construction, and evaluation/reflection. The research was carried out in a macro and two meso cyclic structure, which was also mentioned by McKenney and Reeves (2012), and the cyclical process is shown in Fig. 1.



A1, A2, A3...: Codes of Process Steps | RQ: Research Question

Fig. 1 Micro, meso, and macrocycle processes of the research

Design and development model

In addition to the EDR methodology, the VRID instructional design and development model Chen (2009) was used during the design and development process of the educational virtual reality environment. The VRID model was chosen to effectively manage the design and development process of the virtual reality environment (educational virtual reality environment—EVRECA) developed as part of this study. Essentially, the VRID model has been developed to create learning systems using different approaches that can achieve the desired learning outcomes. The VRID model, which consists of four main parts and 13 sub-steps, is shown in Fig. 2. The process of determining the VRID model is also summarized in steps A1 and A2 in Fig. 5.

Participants

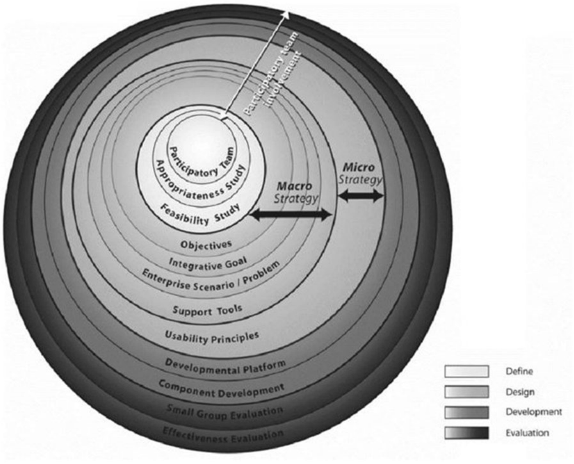
Participatory team

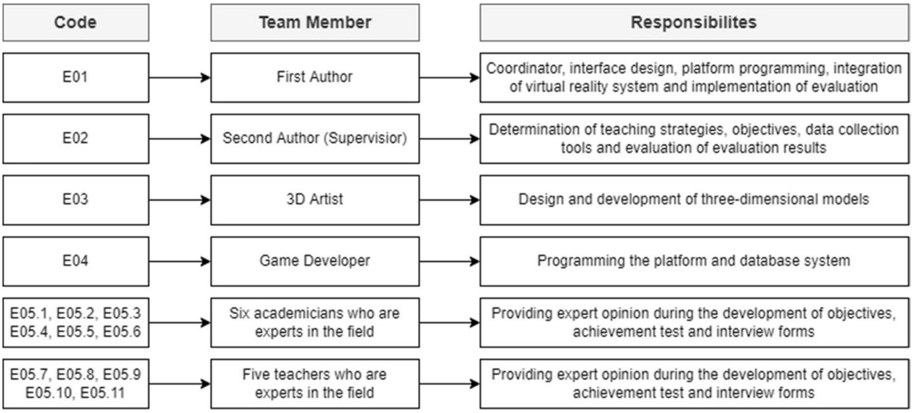
A group of expert participants was determined by the VRID design model (Chen, 2009) followed throughout the research. The opinions of these individuals were taken into consideration during the design and development process of the EVRECA platform, and they also provided support as experts in the development of data collection tools such as the academic achievement test, transfer task, and observation form. The participants in the expert group, their codes of expertise, and their responsibilities are depicted in Fig. 3.

Student study group

Different sampling methods were used in the first and second mesocycle (MC) to determine the student study groups in the research. The students who participated in the evaluation practices of the first mesocycle were determined by the convenience sampling method. On the other hand, the people involved in the evaluation practices carried out within the scope of the second mesocycle of the research were determined by

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





Code	Team Member	Responsibilites
E01	First Author	Coordinator, interface design, platform programming, integration of virtual reality system and implementation of evaluation
E02	Second Author (Supervisior)	Determination of teaching strategies, objectives, data collection tools and evaluation of evaluation results
E03	3D Artist	Design and development of three-dimensional models
E04	Game Developer	Programming the platform and database system
E05.1, E05.2, E05.3 E05.4, E05.5, E05.6	Six academicians who are experts in the field	Providing expert opinion during the development of objectives, achievement test and interview forms
E05.7, E05.8, E05.9 E05.10, E05.11	Five teachers who are experts in the field	Providing expert opinion during the development of objectives, achievement test and interview forms

Fig. 3 The participatory team of the research

the voluntary response sampling method, which is one of the non-random sampling methods. In this context, the demographic data of 18 participants who took part in the research's 1st MC and 2nd MC implementation processes are shown in Table 1.

Data collection tools

The EVRECA platform, developed as part of this research, was evaluated from various perspectives, including its educational impact and technical efficiency. To assess its educational impact, an academic achievement test and a transfer task were administered to measure the learning gains and real-life transfer of knowledge gained through the platform. In addition to these evaluations, scales were used to assess the cognitive load levels, levels of sense of presence, and pleasure-arousal levels of the participants. The technical efficiency of the platform was also analysed using two different analysis programs. The data collection tools used in the study, the study group they were applied to, and the research questions they aimed to answer are presented in Table 2.

Table 1 Student study group of the research

		1st meso cycle ($n=4$)	2nd meso cycle ($n=14$)
Gender	Male	3	12
	Female	1	2
Education level	Associate degree	0	7
	Undergraduate	2	7
	Graduate	2	0
Gaming experience	Yes	2	7
	No	2	7
VR experience	Yes	2	9
	No	2	5

Table 2 Data collection tools, research questions and study groups

Data collection tool	Research question	Student study group
Academic achievement test	1, 2	2nd MC
Transfer task	2	2nd MC
Subjective rating scale	3	1st MC and 2nd MC
Presence questionnaire	3	1st MC and 2nd MC
Affect grid	3	1st MC and 2nd MC
Technical analysis applications	4	1st MC and 2nd MC
Observation form	1, 2, 3, 4	1st MC and 2nd MC

Academic achievement test

The researchers developed the Academic Achievement Test (AAT). They applied it as a pre-test, post-test, and retention test to determine the learning levels of the participants in the cognitive dimension during the second assessment application process. AAT has been prepared as a multiple-choice test with 36 questions covering 29 attainments included in the educational outcomes and measuring the level of knowledge. Three of the questions were prepared to measure the participants' knowledge about the concept of the IoT, 16 of them about physical circuit elements, and 17 of them about block-based coding and programming components. The item specification table based on AAT sub-dimensions of the questions are presented in Table 3. Examples of prepared questions are given in Appendix 1.

Content validity studies of the AAT were carried out based on the processing steps developed by Davis (1992), and the content validity index for the entire test was determined as 0.98. Within the scope of reliability studies, the test was administered to 162 higher education students who were not included in the evaluation process of this study, and the average item difficulty index of the test was 0.64, the average item discrimination index was 0.48, and the KR-20 reliability coefficient was 0.87.

Transfer task

Transfer task (TT) was developed by the researchers and was used in the second evaluation application process to determine the level of participants' ability to transfer the

Table 3 AAT question specification table

Sub-dimensions	Questions
Concept of IoT	1, 2, 27
Physical circuit elements	3, 4, 5, 6, 7, 8, 11, 17, 21, 22, 23, 24, 25, 28, 29, 33
Block-based programming	9, 10, 12, 13, 14, 15, 16, 18, 19, 20, 26, 30, 31, 32, 34, 35, 36

knowledge they gained after the training in the VR environment to real life. TT was developed in a structure consisting of five open-ended questions covering 26 attainments in the list of attainments and measuring the skill level. The participants were given real physical circuit elements and were expected to set up the physical circuit correctly and to perform block-based coding in accordance with the scenario in the transfer task. The scenario and questions in the TT were structured differently from the training projects given on the EVRECA platform. Examples of the prepared questions are presented in Appendix 2.

Content validity studies of TT were carried out based on the processing steps developed by Davis (1992), and the content validity index for the entire test was determined as 0.96. In addition, a 44-item checklist was prepared for the evaluation of the transfer task, and this checklist was checked by two experts during the assessment of the transfer task. In order to ensure the reliability of the checklist and assessments, the Cohen's Kappa coefficient of agreement between the evaluators of the transfer task was calculated and determined as 0.94. Examples of the items in the checklist are presented in Appendix 2.

Subjective rating scale

The Subjective Rating Scale (SRS) was used at the end of the application to measure the level of cognitive load on the participants after the training in a VR environment. The scale determining the cognitive load levels of the participants was first developed by Paas and Van Merriënboer (1993) and adapted to the mother tongue of the study group by Kılıç and Karadeniz (2004). The Cronbach Alpha internal consistency coefficient was determined as 0.90 in the original version of the single-factor and nine-point scale.

Presence questionnaire

The presence questionnaire (PQ) was used to determine how much sense of presence the people who experienced the developed VR environment experienced in the environment. The scale, which determines the level of SoP in the virtual reality environment, was first developed by Witmer et al. (2005) under the name PQ. The adaptation of the PQ to the mother tongue of the study group was carried out by Gökoğlu and Çakıroğlu (2019), and the Cronbach Alpha internal consistency coefficient was calculated as 0.84.

Affect grid

The affect grid (AG) was used to determine the emotional state and arousal levels of people who experience the VR environment. The scale was first developed by Russell et al. (1989). The scale adaptation to the study group's mother tongue was carried out by Aydın et al. (2011). The AG has an orthogonal structure and consists of two intertwined scales. The scale's left half of the cage expresses unpleasant emotions, and the right half expresses pleasant/positive emotions. This situation on the horizontal axis is described as the "Pleasure" scale structure. The vertical dimension of the cage indicates the arousal level of the participants. This axis is accepted as the "Arousal" scale structure.

Observation form

The observation form developed by the researchers was used to record the problems, technical issues, comments, observations of the researcher, and the psychological and physical discomforts that the participants may experience during the practices they performed in the VR environment.

Technical analysis applications

To examine the technical efficiency of the first and second versions of the EVRECA developed within the scope of the research, the FPS, latency, draw call (batch), and polygon count values provided by the platform to the users were first analysed with the Unity Stats tool. Then, to ensure the reliability of the data obtained through Unity Stats, the FPS values obtained from Unity Stats were analysed with a second program using Graphy, which is available in the Unity Asset Store and published free of charge.

Practice process

The study's 1st MC and 2nd MC application processes were carried out in a classroom in the first author's institution. The classroom has been made suitable for the VR experience, and care has been taken to disinfect and ventilate it in accordance with the pandemic conditions. In order to realize the VR application, HTC Vive VR base stations are fixed to the two corners of the classroom, 205 centimetres above the ground. The range of motion for the applications was then set to 4.7 × 2.6 m. The practice process was carried out in a single session with each participant separately. The practices were completed in an average of 72.5 min. Among the participants, the image of K03 during the VR practice is presented in Fig. 4a, and the image of K15 during the transfer task (practice exam) is shown in Fig. 4b.

During the training process in EVRECA platform, the participants first received information on what IoT is and had the opportunity to examine 3D designs of physical circuit elements, which are modelled exactly as they are in reality, from every angle. This allowed them to become familiar with all the physical circuit elements in the virtual reality environment. Afterwards, the participants, who received video content training on block-based coding, saw the interface of the Wyliodrin Studio software and had the chance to test block-based coding parts using the drag-and-drop method. Participants assigned to the project task first saw real-life video content of the task they were going to perform, and then had the opportunity to examine the structural models in three dimensions. Afterwards,


a. K03 VR practice

b. K15 practice exam

Fig. 4 Practice environment

the participants were asked to gather the physical circuit elements needed to perform the task. This also allowed the participants to demonstrate their recognition of physical circuit elements in the VR environment. In the final stage, participants were expected to assemble physical circuit elements as they would in real life. This process was structured exactly as it would be in real life in the VR environment, including features such as plugging in and disconnecting. Finally, the participants completed the software parts of the project by bringing together the correct code block pieces using the drag-and-drop method. By completing three different projects that involved all these stages, the participants learned how to use many different physical circuit elements and sensors. They also learned about many different code block structures, code loops, and programming structures. In the virtual reality environment, these features were presented to the participants as they would be in real life.

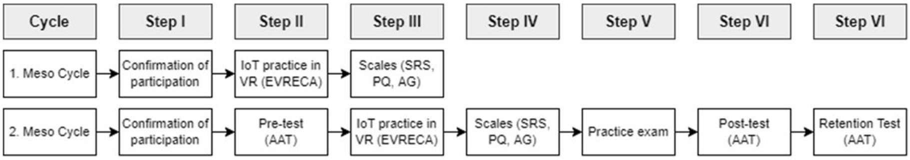
The steps performed after the IoT trainings were presented to the participants in the same order. First, the participants were informed about the EVRECA platform and the practice process, and then an academic achievement test was administered as a pre-test. Next, the participants received IoT training within the EVRECA platform and completed their project tasks. After completing the training in the VR environment, scales (SRS, PQ and AG) were administered to the participants. In the next step, real physical circuit elements, a computer, and a transfer task were given to the participants, and they were expected to complete the project in accordance with the scenario in the TT (Fig. 4b). Finally, the academic achievement test was administered to the participants as a post-test. After this process was completed, a retention test was administered after three weeks. In the 1st MC evaluation study, academic achievement test and transfer task were not performed, unlike the evaluation study in the second meso cycle. The entire implementation process is summarized in Fig. 5.

Design and development of EVRECA

First meso cycle

The analysis and exploration phase of the 1st MC of the research and the steps performed during the design and construction phase are shown in Fig. 6. The design model selection criteria are given in Fig. 7. Finally, the general structure and operation of the EVRECA platform, which was revealed as a result of the design framework and development determined in the design and construction step, is presented in Fig. 8.

The overall scene design of the EVRECA is shown in Fig. 8a. The participants first log into the system on the platform, receive training on how to use the environment (Fig. 8b - orientation section), and then move on to the info school (Fig. 8c). In this section, the participants get to know the physical components for IoT training and then take Wyliodrin Studio and block-based coding training. The participant who completes these



Cycle	Step I	Step II	Step III	Step IV	Step V	Step VI	Step VI
1. Meso Cycle	Confirmation of participation	IoT practice in VR (EVRECA)	Scales (SRS, PQ, AG)				
2. Meso Cycle	Confirmation of participation	Pre-test (AAT)	IoT practice in VR (EVRECA)	Scales (SRS, PQ, AG)	Practice exam	Post-test (AAT)	Retention Test (AAT)

Fig. 5 Practice process

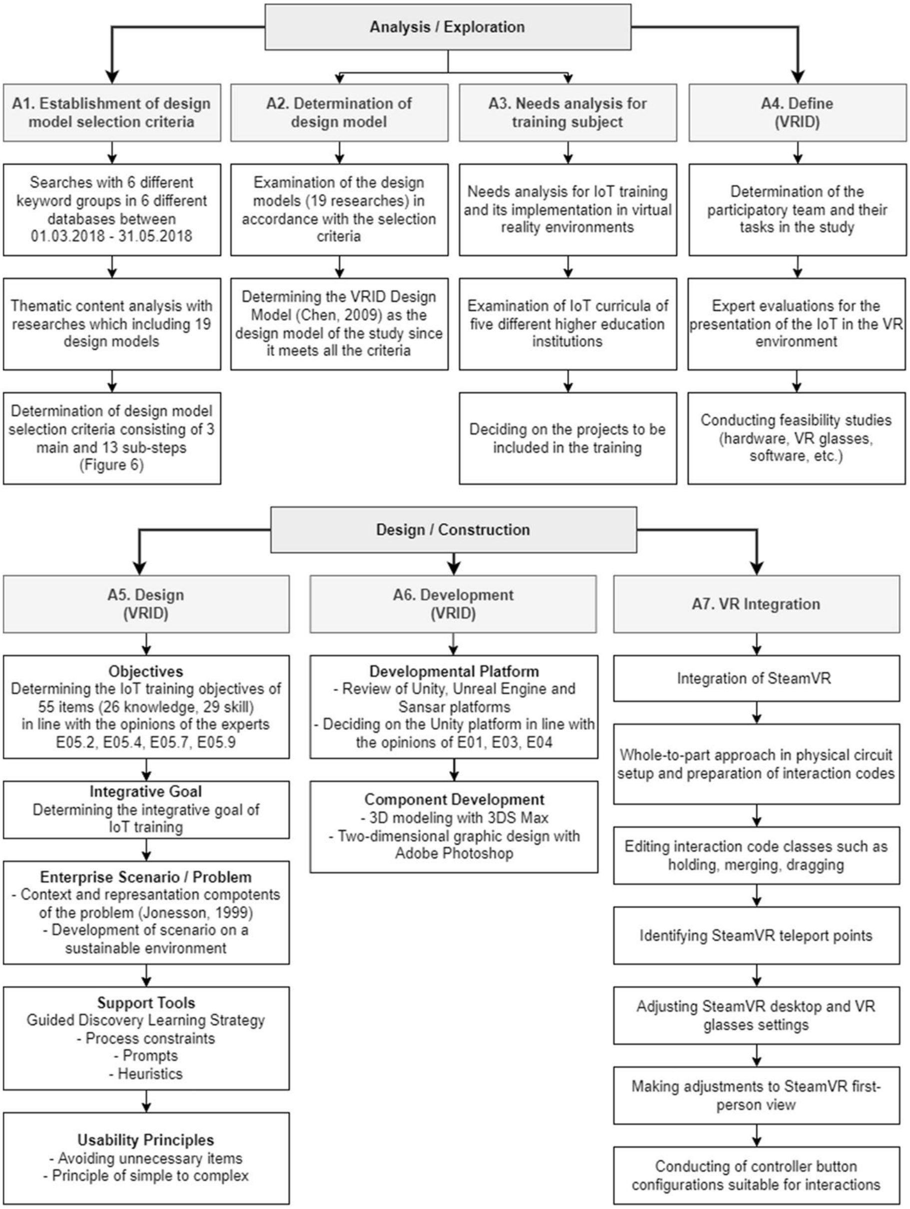
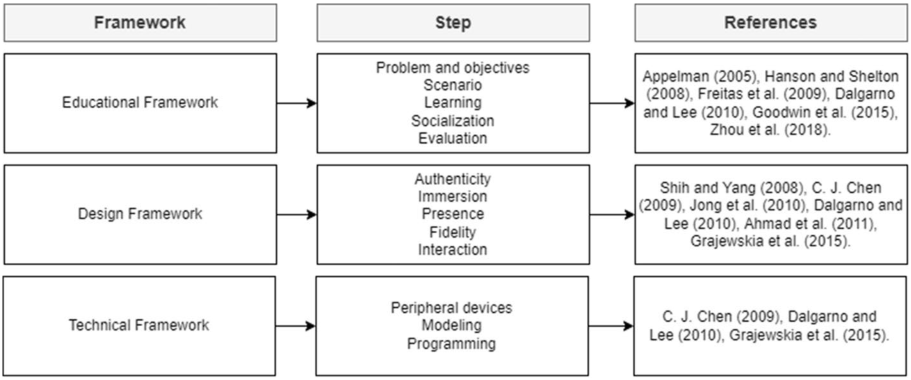


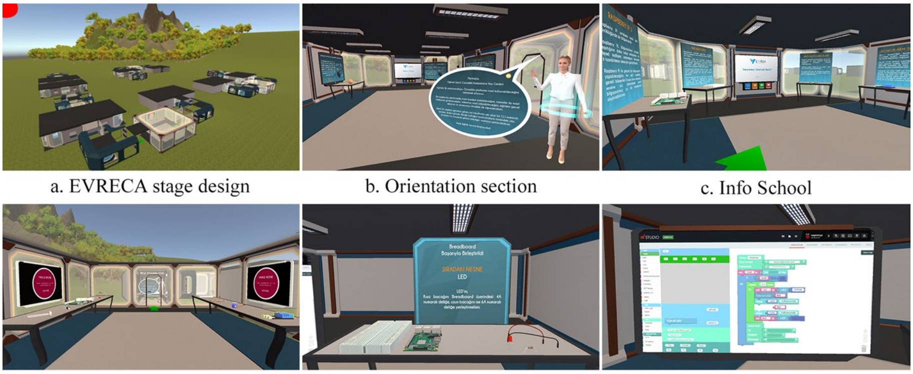
Fig. 6 First mesocycle analysis/exploration and design/construction processes

pieces of training moves on to the first project station. In this station, the participants, who received training on the project aimed to be realized first, collect the objects they will use in the second room (Fig. 8d - object collection section). After performing the physical circuit build activity (Fig. 8e) and block-based programming (Fig. 8f) in the last room, they move on to the second and third project stations. You can click this link



Framework	Step	References
Educational Framework	Problem and objectives Scenario Learning Socialization Evaluation	Appelman (2005), Hanson and Shelton (2008), Freitas et al. (2009), Dalgarno and Lee (2010), Goodwin et al. (2015), Zhou et al. (2018).
Design Framework	Authenticity Immersion Presence Fidelity Interaction	Shih and Yang (2008), C. J. Chen (2009), Jong et al. (2010), Dalgarno and Lee (2010), Ahmad et al. (2011), Grajewskia et al. (2015).
Technical Framework	Peripheral devices Modeling Programming	C. J. Chen (2009), Dalgarno and Lee (2010), Grajewskia et al. (2015).

Fig. 7 Design model selection criteria



a. EVRECA stage design b. Orientation section c. Info School

d. Object collection section e. Circuit build phase f. Block-based programming section

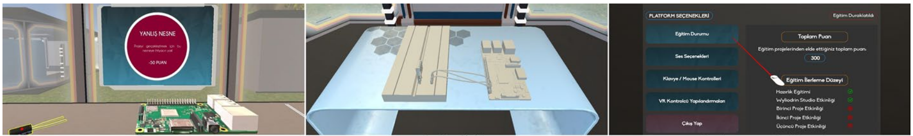
Fig. 8 EVRECA screenshots

to access a sample video created from the screenshots recorded during the events of the participants and this link to access the demo version of the EVRECA platform.

On the EVRECA platform, the IoT training and project training that participants complete, as well as the time they spend completing tasks in the projects, are recorded in a database. The platform also records data such as how long the participants stayed inside when they entered the platform, how long they took to complete the entire training process, and their last location. This allows the participants' data to be recorded not only through observations but also through the system. In addition to all these features, the platform also includes a three-dimensional educational agent that helps guide participants through the training process.

Second meso cycle

In this study, in which GDL was used as a supportive teaching strategy, in addition to the process constraints, prompts (Fig. 9a), intuitive reminders strategies in the first version, performance dashboard (Fig. 9c), and scaffolding (Fig. 9b) strategies were also utilized in the second version of the platform. Examples of the code blocks added to the platform as a



a. Prompts b. Scaffolds c. Performance dashboards

Fig. 9 Guided discovery learning strategies

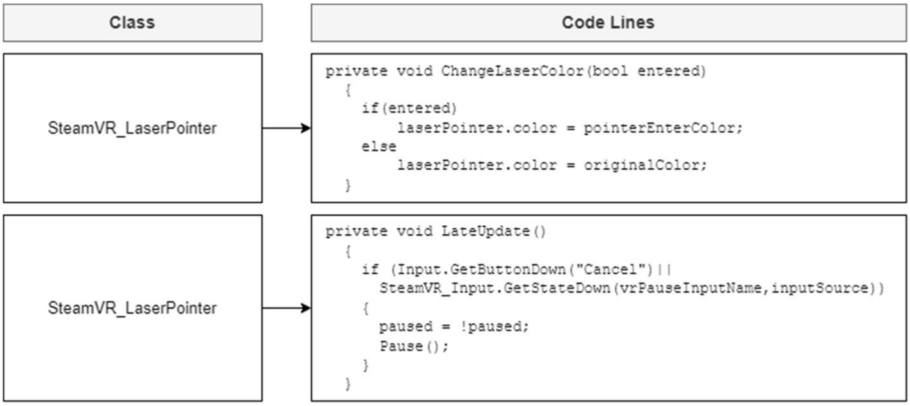
result of the operations performed in the VR Optimization steps are given in Fig. 10. The analysis and exploration phase of the 2nd MC of the research and the steps performed during the design and construction phase are shown in Fig. 11.

Results

First evaluation

In the last step of the first mesocycle, a small group evaluation application was carried out with four participants (1st meso cycle student study group—Table 1). This evaluation was conducted to observe the users' experience of the platform, to identify areas for improvement and to create the infrastructure for the second application. In this context, the problems and the problems encountered during the first evaluation application process were collected on the observation form and the feedback from the participants and the researcher's observations. As a result of the data obtained, the main problems encountered during the implementation and the observation notes are listed below:

- The teleportation points in the first version of the platform are sometimes not visible due to the ground,
- Physical objects appear larger than they are when handled,
- Long training videos,
- Problems observed in some parts of the platform floor (vibration, sliding, etc.),



Class	Code Lines
SteamVR_LaserPointer	see code below

SteamVR_LaserPointer

```
private void ChangeLaserColor(bool entered)
  {
    if(entered)
        laserPointer.color = pointerEnterColor;
    else
        laserPointer.color = originalColor;
  }
```

SteamVR_LaserPointer

```
private void LateUpdate()
  {
    if (Input.GetButtonDown("Cancel")||
      SteamVR_Input.GetStateDown(vrPauseInputName,inputSource))
    {
      paused = !paused;
      Pause();
    }
  }
```

Fig. 10 VR optimization sample code fragments

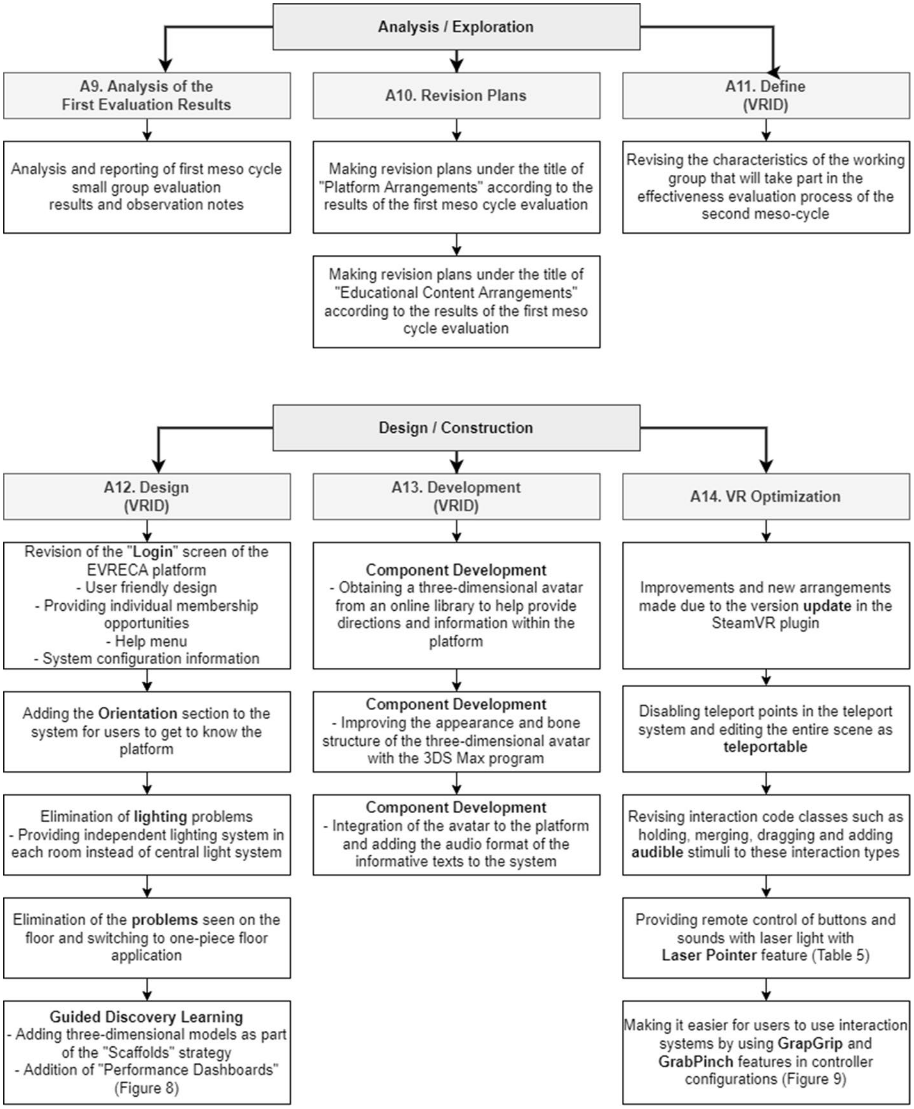


Fig. 11 Second mesocycle analysis/exploration and design/construction processes

- The orientation section requests the participants at the entrance to the application,
- A suggestion that in-app redirects could be improved (e.g., 3D Avatar),
- Participants request to see their performance improvement,
- Participants requested to see three-dimensional sketch models of projects instead of videos.

At this stage, the sense of presence, cognitive load, and pleasure-arousal level of the four participants who participated in the small group evaluation were also measured. This was done to test the level of immersion of the first version of the platform. In addition, technical analyses of the first version of the EVRECA were conducted and improvements were made based on the results. When the scale data obtained from the participants at the end of these applications were evaluated, it was found that the average level of presence (SoP) was 125.75, the average cognitive load level was 2.75, the average pleasure level was 7.25, and the average arousal level was 7.00. In addition to these data, it was determined that the average FPS value offered by EVRECA_v.0.1 is 50.1, the average latency is 29.2 milliseconds, the draw call number is 2540, and the polygon number is 391,400. These data are presented under the headings "Cognitive and psychological effects" and "Technical efficiency of the platform,“ where the results of the second evaluation are presented in comparison to show the evolution of the structural features offered by the first and second versions of the EVRECA platform. In addition, these data are also discussed in the discussion section.

Second evaluation

Academic achievement levels

The AAT was administered to the participants as a pre-test and post-test before and after the practices. At the same time, it was administered again as a retention test at the end of the 21–28 days after the practice process. If the questions in the AAT are answered correctly, it is evaluated as 1 point, and if it is answered incorrectly, it is assessed as 0 points. The maximum point that the participants can make in the test is 36. Table 4 contains descriptive statistics for the pre-test, post-test, and retention tests.

To examine whether the IoT training on the EVRECA platform makes a difference in the participants' success, the different analyses were carried out with the Wilcoxon paired-sample test, one of the non-parametric tests since the number of participants was not sufficient for the parametric tests. The results of the analysis are shown in Table 5.

When the results of the analysis were examined, a significant difference was observed between the average score of the exam performed before the IoT training conducted on the EVRECA platform ($\bar{x}_{\text{pre-test}} = 19.79$) and the average score of the exam performed after the training ($\bar{x}_{\text{post-test}} = 28.57$) ($z = -3.31$, $p < 0.05$). The said difference was in favour of the post-test. This shows that the training received on the EVRECA platform has a significant effect ($r = 0.89$) on the participants.

In addition to the analyses used for finding differences between the pre-test and post-test mean scores, a Wilcoxon paired-sample test was utilized to analyse the post-test and the retention test to check the retention of the training on the participants, and the results are shown in Table 5. When the results were examined, there was no significant difference between the post-test test scores ($\bar{x}_{\text{post-test}} = 28.57$) and the retention test exam scores ($\bar{x}_{\text{retention-test}} = 28.14$) after the training on the EVRECA platform ($z = -0.86$, $p < 0.05$).

Table 4 Descriptive statistics of AAT and TT

	n	M	SD
AAT Pre-test	14	19.79	5.13
AAT Post-test	14	28.57	2.65
AAT Retention	14	28.14	3.05
Transfer Task	14	71.43	6.36

Table 5 AAT Wilcoxon test results

	Ranks	n	Mean rank		Z	p
Post-test Pre-test	Negative ranks	0	0.00	0.00	– 3.31	0.00
	Positive ranks	14	7.50	105.00		
	Ties	0				
	Total	14				
Retention test Post-test	Negative ranks	8	7.19	57.50	−0.86	0.39
	Positive ranks	0	6.70	33.50		
	Ties	1				
	Total	14				

Academic success and transfer to real-life

After the training on the EVRECA platform real physical circuit elements, a computer, and a transfer task were given to the participants, and they were expected to complete the project in accordance with the scenario in the TT (Fig. 4b). The descriptive statistics of the transfer task results, which consist of a total of five questions and test the participants' ability to integrate the information they have learned and the new information they encounter, are given in Table 4. In addition, the Spearman rank correlation coefficient was used to determine if there is a relationship between the participants' AAT post-test, retention test, and transfer task scores after IoT training on the EVRECA platform and to assess the reliability of the data. Analysis results are shown in Table 6.

When the analysis results in Table 6 are examined, there is a very high level of 0.86 in the positive direction between the post-test scores at the $p < 0.01$ level and the transfer task score; It was observed that there was a positive correlation of 0.77 between the retention test scores and the transfer task scores. Based on these data, it was concluded that there is a significant correlation between the participants' academic achievement test and retention test scores and the transfer task results and that the knowledge gained in the virtual reality environment can be transferred to real life.

Cognitive and psychological effects

At this stage, the descriptive statistics of the cognitive load, sense of presence, pleasure, and arousal data were examined. The data compared with the first and second evaluation are shown in Table 7.

Table 6 Academic achievement, retention, and transfer task relationship analysis results

Spearman's rho correlation analysis[a]	Transfer task	Post-test	Retention test
Transfer task	1.00	0.86^{**}	0.77^{**}
Post-test		1.00	0.84
Retention test			1.00

[a] $n = 14$

$^{**}p < 0.01$

Table 7 Descriptive statistics of cognitive load, sense of presence, pleasure and arousal levels

	First evaluation ($n=4$)		Second evaluation ($n=14$)	
	M	SD	M	SD
Cognitive load	2.75	1.71	2.07	1.14
Presence	125.75	3.00	127.93	6.50
Pleasure	7.25	1.30	8.00	1.04
Arousal	7.00	0.82	7.93	0.92

It can be stated that after the improvement studies carried out following the first evaluation, the platform caused less cognitive load in the second evaluation application and provided a higher sense of presence, pleasure, and arousal.

After the IoT training on the EVRECA platform, the Spearman Rank Correlation Coefficient was examined to determine whether there is a relationship between the cognitive load, sense of presence, pleasure, arousal, post-test, retention test, and transfer task scores of the participants. Analysis results are shown in Table 8.

The analysis results in Table 8 were examined at the $p<0.05$ level; first, the cognitive, and psychological effects were evaluated. It was observed that there was a weak negative correlation between the cognitive loading of the participants and the level of their sense of presence. In addition, it was observed that there was a weak positive correlation between the cognitive loading of the participants and their arousal and pleasure levels. On the other hand, it was observed that there was a moderate positive correlation between the participants' levels of presence and their pleasure levels.

During the analysis, other potential factors that may impact the cognitive and psychological aspects of the participants were also taken into consideration. It was believed that, in particular, the game-playing habits and virtual reality experiences of the participants could significantly influence their cognitive and psychological aspects. As such, it was investigated whether the cognitive and psychological scale data differed based on the participants' virtual reality experience and game-playing habits. Descriptive statistics of the findings are presented in Table 9. These obtained data and results were also discussed in the discussion section.

When the participant data presented in Table 9 were examined, it was determined that the average level of cognitive load (2.29) of the group playing games was higher than those who did not play (1.86). On the other hand, the mean scores of the participants who played games in the level of the SoP (126.71), pleasure (7.71), and arousal (7.71) were found to be lower than the data of the participants who did not play games (129.14; 8.29; 8.14).

Technical efficiency of the platform

As in the first version of the EVRECA platform, analyses were also conducted to determine the level of technical efficiency achieved during the second version experience. First, the technical efficiency of the platform was analysed using the Unity Stats tool. Then, the FPS values obtained from Unity Stats were checked with a second program using the Graphy plugin. The data obtained at the end of the first and second evaluations from both analysis tools are shown in Table 10.

As shown in Table 10, the average FPS value formed during the use of the platform was measured as 60.4 by the Unity Stats analysis tool, while it was determined as 57 by

Table 8 Relationship analysis results of scale, achievement test and transfer task scores

Spearman's rho correlation analysis[a]	Cognitive load	Presence	Pleasure	Arousal	Post test	Transfer task	Retention test
Cognitive load	1.00	-0.19^{*}	-0.14	0.23	0.15	0.25	0.24
Presence		1.00	0.57^{*}	0.23	0.06	0.00	0.10
Pleasure			1.00	0.65^{*}	0.08	0.00	-0.04
Arousal				1.00	0.00	-0.00	-0.03
Post test					1.00	0.86^{**}	0.84^{**}
Transfer task						1.00	0.77^{**}
Retention test							1.00

[a] $n = 14$

*$p < 0.05$

**$p < 0.01$

Table 9 Descriptive statistics of the scales according to gaming and VR experience situations

		n	M	SD
Those who play games	Cognitive load	7	2.29	0.47
	Presence	7	126.71	2.41
Those who do not play games	Cognitive load	7	1.86	0.40
	Presence	7	129.14	2.60
Those with VR experience	Cognitive load	9	2.44	0.38
	Presence	9	128.00	2.40
Those without VR experience	Cognitive load	5	1.40	0.40
	Presence	5	127.80	2.58

Table 10 EVRECA v.1.0 and v.2.0 technical analysis values

		Unity Stats	Graphy		
			Minimum	Mean	Maximum
First Evaluation [v.1.0]	Frame per second (FPS)	50.1	22	50	58
	Latency (ms)	29.2		30	
	Draw call count	2540		–	
	Polygon count	391.490		–	
s Evaluation [v.2.0]	Frame per second (FPS)	60.4	24	57	67
	Latency (ms)	16.6		16.5	
	Draw call count	1319		–	
	Polygon count	489.900		–	

Graphy. However, Graphy also gave the information that the maximum FPS value is 67. On the other hand, Graphy determined the latency to be 16.5 milliseconds during the display of the platform at an average of 60 FPS. Similarly, the Unity Stats analysis tool has determined the processor latency experienced during the experience of the platform as 16.6 milliseconds.

Discussion and conclusion

Conclusion and discussion on academic success and transfer to real life

As in many similar studies, it was concluded in this study that virtual reality positively affects academic achievement (Al Amri et al., 2020; Srinivasa et al., 2021; Tacgin, 2020). In addition, the retention test results of the participants, which were examined in the period after the training, also showed that the training given in the VR environment had a lasting effect. Therefore, when evaluated from this point of view, it can be stated that the results obtained in the current study support the literature that the education carried out in VR environments positively affects academic achievement and has a permanent effect. As a matter of fact, in many compilations and meta-analysis studies examining educational studies conducted on VR platforms, it has been reported that the academic success, motivation, and courage of those who receive education in these environments increase (Peixoto et al., 2021; Pellas et al., 2020; Soliman et al., 2021).

The problems of not using psychomotor skills and testing learning outcomes only at the cognitive level (Di Natale et al., 2020; Holly et al., 2021; Lege & Bonner, 2020) in most of the training carried out in VR environments, mentioned by many researchers in the literature, were particularly taken into account in this study. At the end of the practices carried out in this context, it has been determined that there is a very high level of correlation between the participant's scores in the AAT and the TT. At this point, an education subject that allows the use of psychomotor skills provides learning at the cognitive and skill level; In addition, it can be stated that this result supports the literature results (Ishak et al., 2020; Mohamed et al., 2018) revealed that the subject of the IoT has an educational structure that can be given in VR environments. In addition, the current study results are thought to be a response to Lege and Bonner (2020) comment that "However, it is imperative that educators should move beyond this honeymoon phase and focus on the pedagogies and experiences that VR makes possible".

When the ATT and TT results of the participants were examined, it was seen that the level of success at the point of physical circuit elements and installation could not be achieved in the block-based coding process. Although they perform their activities by holding and dragging and dropping code block pieces, since the concept of programming has an abstract structure, it is thought that the participants cannot internalize a structure that does not have a direct counterpart in real life as in physical circuit elements. As a result, it was concluded that the learners had more learning experiences in the departments where they could use their psychomotor skills. At this point, it is possible to say that the training in which psychomotor skills can be used in the VR environment affects the cognitive learning levels of the participants and their ability to transfer the acquired knowledge to real-life in a positive way.

Conclusion and discussion on cognitive and psychological effects

The results of this study show that the developed environment, on the one hand, provides the participants with a high level of SoP, on the other hand, the participants experience a low level of cognitive load in the environment. In recent studies, it has been stated that the level of presence in immersive VR environments provides a higher SoP compared to desktop environments or semi-immersive VR (Schwind et al., 2019; Servotte et al., 2020). Therefore, from the aforementioned point of view, it is thought that the high SoP found at the end of the study supports the literature.

The remarkable result of the current study, in particular the SoP, is that there is no relationship between the level of presence of the participants and the level of academic achievement and transfer of learned knowledge to real life. However, in recent studies, it has been reported that the high level of presence experienced by the participants positively affects learning (Fischer et al., 2021; Lerner et al., 2020). At this point, when the possible reasons for the lack of a relationship between the SoP and learning level in the current study are evaluated, it is thought that one of the possible reasons is that half of the people in the study group have experience of playing games. When the results are examined, although there is no statistically significant difference, it has been determined that the average SoP of people with gaming experience is lower than those without gaming experience. It is thought that participants with gaming experience three-dimensional environments more and are less affected by the current VR environment compared to those who do not play games. Another possible reason was considered as the number of participants.

When the effect of VR environments on cognitive load is examined, it is seen that different results are revealed in the literature. While many researchers report that VR does not increase the cognitive load (Armougum et al., 2019; Liu et al., 2021; Topuz, 2018), another recent study by Parong and Mayer (2021) stated that there is a higher cognitive load in VR environments than in desktop learning environments, and this situation negatively affects learning. At the end of this study, it was seen that the cognitive load levels of the participants were low, but there was no relationship between cognitive load and AAT and TT scores. Therefore, it is thought that one of the factors affecting the low level of cognitive load of the participants in the high mean scores in the SoP. Similarly, it is believed that the participants' high levels of pleasure and arousal also affect their cognitive load levels. On the other hand, although there was no statistically significant difference, it was determined that the cognitive load levels of the participants with VR and gaming experiences were higher than the others. As a matter of fact, it has been observed that those who have VR and gaming experiences pay more attention to the details of the platform. At this point, it was concluded that the inexperienced participants paid less attention to the details in the environment due to the high SoP, pleasure, and arousal they experienced, and their cognitive load levels were lower for the reasons stated.

Few studies have been conducted on the relationship between the sense of presence and cognitive load levels experienced in VR environments. Researchers such as Armougum et al. (2019) and Hite et al. (2019) drew attention to this situation and recommended research on concepts that might be associated with cognitive load. In a recent study, Huang et al. (2020) emphasized that the data obtained in terms of the relationship between SoP and cognitive load and the effect of these two concepts on learning are inconsistent and unpredictable, so they should be examined in more depth. Similarly, at the end of this study, it was determined that there were different relationships between the SoP and the level of cognitive load after the first and second evaluations. After the first evaluation application, it was observed that there was a very high level of negative correlation between the sense of presence and cognitive load; At the end of the second evaluation application, which was carried out with more participants, it was determined that there was a weak negative relationship. On the other hand, the results of the study show that the relationship between cognitive load and sense of presence is negative after both applications. From this point of view, it is possible to say that the relationship between cognitive load and sense of presence is in the opposite direction. Still, more studies are needed at the level of the relationship.

Conclusion and discussion on technical efficiency

As a result of the analyses carried out in the research, the average FPS value in the first version of the EVRECA platform was 50.1; The FPS value in the second version was determined to be 60. After the evaluation implementation carried out with the first version of the platform, it was observed that the participants faced many problems and had difficulty experiencing the environment effectively. On the other hand, after the second evaluation application with EVRECA v.2.0, which was revealed after the improvement works, it was seen that the users who experienced the 60 FPS environment encountered almost no errors and were able to perform the training activities fluently. In the light of the research findings, it was concluded that the FPS value of the environment affects the VR experience of the participants. When the literature is examined, it is seen in the research conducted by Hvass et al. (2017) that the number of frames displayed per second affects the VR experience. In another recent study, Zhang (2020) found that users may encounter problems such as dizziness, headache, nausea, and disorientation in VR environment experiences with an FPS value below 50 FPS.

Another technical factor affecting the VR environment experience is the latency that the environment creates on the computer processor. The analyses performed after the first evaluation application showed that the first version of the platform had an average processor latency of 30 milliseconds; this indicates that the second version causes a delay of 16.5 milliseconds. Although it is not possible to reach many references at the optimum level of processor latency, Raaen and Kjellmo (2015) suggest that delays between 17 and 33 milliseconds can be experienced in a system that offers 60 FPS images, but this time should be below 20 milliseconds for VR environments. The current study results also show that the VR experience in the second version is much better than the first version and supports the results presented by Raaen and Kjellmo (2015) in the literature.

Considering the findings of the research, it is possible to say that the improvements made in the second version of the platform have significantly reduced the number of incorrect drawings in the scene, and the polygon count has been affected relatively less, despite the addition of many new three-dimensional objects and projects. Looking at the literature, in a recent study that mentioned these technical features, It has been reported that when the polygon values in the environment are reduced by 30–40%, the stage performance increases, and the discomfort experienced by the participants decreases (Fu et al., 2021). Furthermore, in another study, when the data in the VR environment that offers a good experience to its users are examined; It was determined that the average number of instant drawings created on the scene is 3007, and the average polygon count is 3.2 million (Surer et al., 2021). In the light of all these data, although it is not correct to talk about an optimal reference range for draw call and polygon counts, it can be stated that the values of the developed platform are at a reasonable level.

Limitations and future study

Limitations

The measures taken at the national and international level due to the Covid-19 pandemic experienced during the period of the research (failure to continue face-to-face education, curfews, full closure practices, transportation bans, etc.) caused suspensions and delays in the evaluation processes with learners. Due to these suspensions and delays, the total number of participants in the study groups is limited to 18 students living in the province where the application is made and included in the target group. In addition, the projects in the IoT training are limited to the Raspberry Pi 3 development board and the physical circuit elements in the EVRECA platform. Moreover, block-based programming elements are limited to the block-based coding features offered by the Wyliodrin Studio software used in education.

Suggestions

In line with the research results suggestions were made primarily for educators, instructional designers, and academics regarding the development of an educational virtual reality environment and/or future studies for the education process to be carried out in this environment. At this point, it is recommended first to investigate the effects of different educational content and VR environments in which psychomotor skills are used on learning at cognitive and skill levels. In addition, in new studies, the participants' learning experiences can be controlled by adding the unlimited trial feature to the physical circuit building activity of the IoT subject. In addition, the effects of this type of coding on learning can be examined by using text-based coding instead of block-based coding.

It is recommended that researchers working in the field of virtual reality re-examine the effects of SoP and cognitive load on academic achievement and transfer task with a larger study group. Besides, at the end of the study, it was determined that there was a negative relationship between the SoP and cognitive load, but no clear result could be obtained about the level of this relationship. It is recommended that the relationship between the SoP and cognitive load and the level of this relationship be examined in depth with new research to be done.

At the end of the research, it was seen that one of the critical steps during the development of the environment is the integration and optimization of the virtual reality system into the three-dimensional environment. Therefore, it is recommended that VR developers add a process step related to VR integration both to the process and to the new design models to be developed in their future studies and to plan application-specific programming structures by including this step in the development process. In addition, it is recommended that VR environments with different FPS values and latency times are presented to the participants in future studies, and the effect of the relevant technical data on the VR experience is directly examined.

Appendices

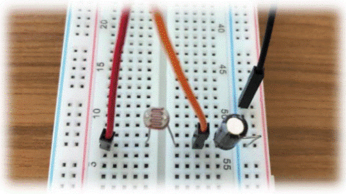
Appendix 1: Academic achievement test question examples

1. Although there are different explanations for the concept of Internet of Things, when considered in the most general sense; Which of the following statements does a student use to describe the Internet of Things more accurately and comprehensively?

A. The Internet of Things is the situation in which different devices can access the Internet.
B. The Internet of Things is the ability of devices to communicate via the Internet.
C. The Internet of Things refers to the situation where smart devices can communicate with people.
D. The internet of things refers to the ability of smart devices to communicate with each other and with people over the internet and transfer information.
E. The Internet of Things refers to the ability of people to communicate with each other and with devices over a wireless network.

6. Light dependent resistors (LDR) provide the perception of the light level of the environment according to the light intensity falling on them. Which of the following is a correct statement for LDR?

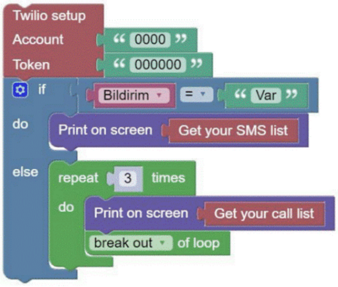
A. LDR has maximum resistance in dark environment
B. LDR has maximum resistance in bright environment
C. LDR changes are linear
D. LDR value is directly proportional to light intensity
E. LDR cannot be considered a sensor



23. A student wants to develop a project within the scope of the internet of things by reading the value from LDR. In which of the following options are the physical pin numbers of Raspberry Pi 3, which the student needs to connect the red, orange, and black cables, correctly?

(One leg of the LDR should be used for power, one leg of the capacitor should be used to prevent short-circuit, and the common legs should be used for communication)

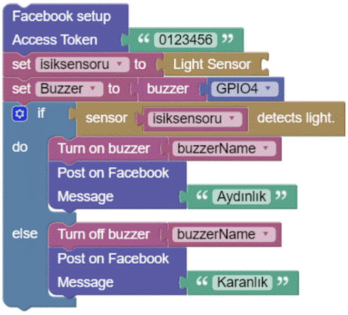
	Red Cable	Orange Cable	Black Cable
A.	1	14	6
B.	1	17	9
C.	17	13	7
D.	17	11	9
E.	17	7	7



```
Twilio setup
Account  “ 0000 ”
Token    “ 000000 ”
if  Bildirim = “ Var ”
do    Print on screen  Get your SMS list
else  repeat 3 times
      do  Print on screen  Get your call list
          break out of loop
```

9. A code block prepared in Wyliodrin Studio is above. Which of the following is not a correct statement about this code block?

A. If the "Bildirim" variable is equal to "Var", the list of text messages in the Twilio account will be printed on the screen.
B. If the "Bildirim" variable is not equal to "Var", the search list in the Twilio account will be printed on the screen.
C. The loop structure inside the Else code block will continue to run if the condition statement is not met.
D. The search list in the Else code block will be printed three times.
E. The loop structure within the Else code block will be terminated after three iterations.

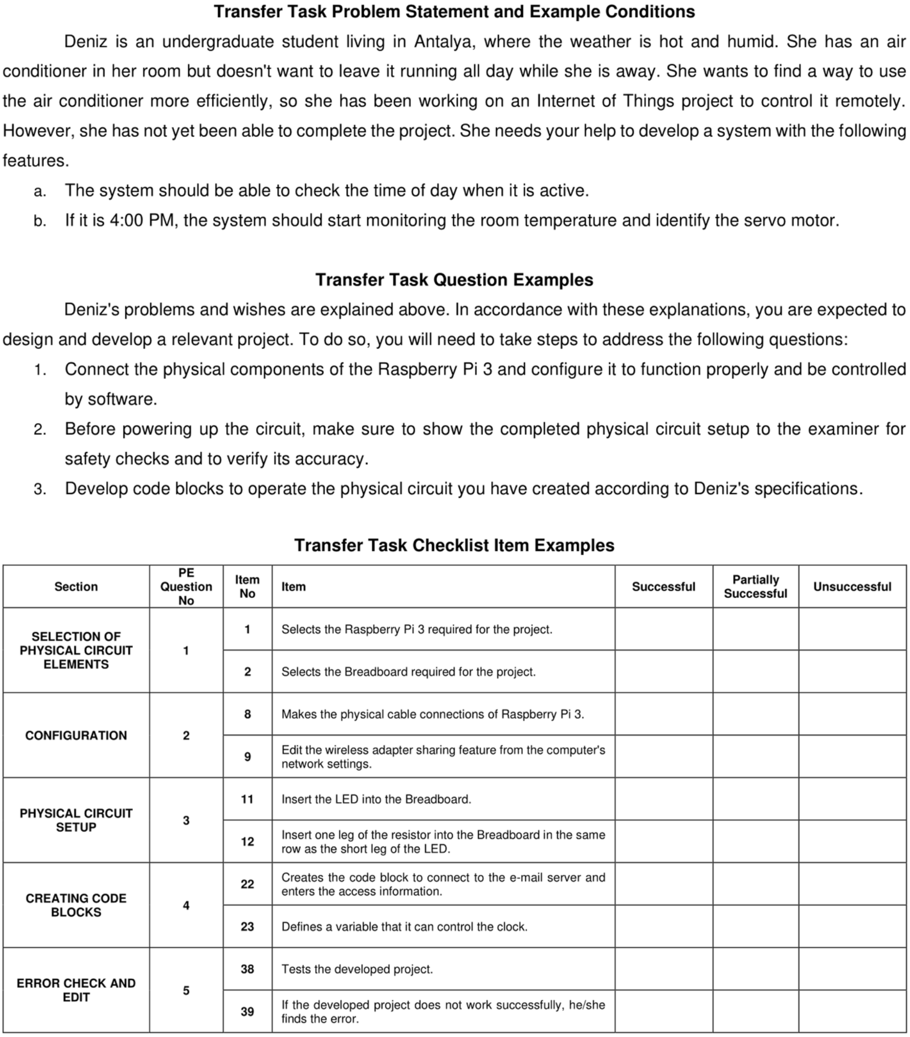


```
Facebook setup
Access Token  “ 0123456 ”
set isiksensoru to  Light Sensor
set Buzzer to  buzzer  GPIO4
if  sensor  isiksensoru  detects light.
do    Turn on buzzer  buzzerName
      Post on Facebook
      Message  “ Aydınlık ”
else  Turn off buzzer  buzzerName
      Post on Facebook
      Message  “ Karanlık ”
```

35. The code block given above does not work successfully. Which of the following options is correct for the program to run successfully?

A. The GPIO Pin to which the light sensor is connected must be entered in the code block.
B. Facebook Access Token information should be edited, and Buzzer names should be changed.
C. Buzzer names should be changed, and loop should be used instead of conditional operator.
D. The GPIO Pin to which the light sensor is connected must be entered and the Buzzer names must be changed.
E. The GPIO Pin that the buzzer is connected to should be changed and the names should be edited.

Appendix 2: Transfer task scenario, question, and checklist item examples



Transfer Task Problem Statement and Example Conditions

Deniz is an undergraduate student living in Antalya, where the weather is hot and humid. She has an air conditioner in her room but doesn't want to leave it running all day while she is away. She wants to find a way to use the air conditioner more efficiently, so she has been working on an Internet of Things project to control it remotely. However, she has not yet been able to complete the project. She needs your help to develop a system with the following features.

a. The system should be able to check the time of day when it is active.
b. If it is 4:00 PM, the system should start monitoring the room temperature and identify the servo motor.

Transfer Task Question Examples

Deniz's problems and wishes are explained above. In accordance with these explanations, you are expected to design and develop a relevant project. To do so, you will need to take steps to address the following questions:

1. Connect the physical components of the Raspberry Pi 3 and configure it to function properly and be controlled by software.
2. Before powering up the circuit, make sure to show the completed physical circuit setup to the examiner for safety checks and to verify its accuracy.
3. Develop code blocks to operate the physical circuit you have created according to Deniz's specifications.

Transfer Task Checklist Item Examples

Section	PE Question No	Item No	Item	Successful	Partially Successful	Unsuccessful
SELECTION OF PHYSICAL CIRCUIT ELEMENTS	1	1	Selects the Raspberry Pi 3 required for the project.			
		2	Selects the Breadboard required for the project.			
CONFIGURATION	2	8	Makes the physical cable connections of Raspberry Pi 3.			
		9	Edit the wireless adapter sharing feature from the computer's network settings.			
PHYSICAL CIRCUIT SETUP	3	11	Insert the LED into the Breadboard.			
		12	Insert one leg of the resistor into the Breadboard in the same row as the short leg of the LED.			
CREATING CODE BLOCKS	4	22	Creates the code block to connect to the e-mail server and enters the access information.			
		23	Defines a variable that it can control the clock.			
ERROR CHECK AND EDIT	5	38	Tests the developed project.			
		39	If the developed project does not work successfully, he/she finds the error.			

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Declarations

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