Virtual Reality Simulation Game for Economics Students: Usability Evaluation

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Annotation. This paper presents experiences in the development and usability evaluation of the Erasmus+ project VR-based simulation tools content for developing economics students' critical thinking, communication, collaboration and creativity skills. The study involved 91 students from 3 countries. The research methodology to determine the relevance of the contentis is based on applying participant method (namely, Event diaries), were Keller's ARCS (attention, relevance, confidence, and satisfaction) motivational design model was used as a guiding strategy. In this study content usability: Relevance scored highest (3.64 out of 5), followed by confidence (3.37 out of 5), attention (3.5 out of 5), and content satisfaction (3.04 out of 5).

Keywords: Virtual reality, Usability, Virtual education, VR-simulation game, High education.

1. Introduction

This paper presents the experiences in the development and usability evaluation of a VR-based simulation game created as part of the Erasmus+ project "Development of a Virtual Learning Space as a Tool for Developing Students' Critical Thinking, Communication, Collaboration and Creativity Skills in the Context of COVID-19" (VILESA, 2022–2024, No. 2021-1-LT-01-KA220-HED-000023551). The aim of the project was to address the challenges of applying modern teaching and learning methods in the social sciences by digitizing study content through the use of a virtual reality platform. The project brought together students and teachers from the Faculty of Economics of Vilnius College (VIKO) (Lithuania), Krakow University of Economics (KUE) (Poland), and EKA University of Applied Sciences (Latvia). 91 students from 3 countries participated in the usability study in two phases to determine the usability of the content.

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ARCS [18] (attention, relevance, confidence, and satisfaction) motivational design model was used as a guiding strategy.

Research objectives: 1. Present the system development cycle: analysis, design, implementation and evaluation; 2. Assess the usability of the content of the developed gamified VR-based training tool among the study participants.

2. Literature review

EBSCOhost and Tailor & Francis online libraries for the last 5 years 2019-2024 have selected 13 studies in the areas of education and professional training where the use of virtual reality (VR) and related technologies help to achieve the expected results.

First of all, in the field of engineering education, studies were considered that involve gamified virtual laboratories and virtual excursions to prepare students for practical classes. For example, in one of the quasi-experimental studies (n = 92), construction students who used VR-laboratories spent 16% less time in physical laboratories and showed better preparedness for experimental work [1]. In another study (n = 41), the influence of virtual tours in ecological representation was studied, where students noted convenience and accessibility the VR-approach, while it is inferior to traditional field research in terms of effectiveness [2].

In the second case, virtual reality is actively used in medical and nursing education to teach clinical skills, simulate emergency situations, and improve interdisciplinary interaction. A quasi-experimental study with the participation of 675 nursing students who studied using VR-simulations found that VR promotes more active involvement (95% active participation compared to 15% in traditional methods) and the development of critical thinking [3]. Also, in the following study (n = 43), where they study metaverse virtual space for collaborative learning of nurses, it showed a significant improvement of satisfaction with training and improvement of group work [4]. VR integration into nursing curricula was well-received. Students and educators reported high usability and positive learning experiences [5].

Moreover, VR is also used in emergency medical training. Namely, the VR-content developed to prepare students for triage in emergency situations showed a high score according to the criteria of relevance (4.23 out of 5) and confidence (3.81 out of 5) [6]. Similarly, VR-training for complex

medical procedures, such as REBOA, allowed to significantly increase the confidence of specialists [7].

The implementation of interactive VR avatars in the education of future pharmacists has been analyzed in the field of pharmacy education. In a multi-stage study (n = 10), it was found that such simulations contribute to better learning and development of practical skills [8].

In addition, the potential of VR in dementia care and training for visually impaired people has been explored. In a pilot study (n = 10) involving professional caregivers, VR training demonstrated high effectiveness in developing empathy and dementia care skills [9]. Another study (n = 20) assessed the usability and effectiveness of multimodal VR interfaces for training visually impaired users used to help develop new skills and to stimulate cognitive improvement [10].

Practice shows that fashion and design education also include elements of virtual reality. Research has shown that students with high spatial skills demonstrate greater satisfaction with distance learning, especially when using the traditional studio approach. At the same time, the perceived usefulness of VR courses largely depends on the level of digital competence of students [11].

In geovisualization, VR and AR are used to study natural landscapes and geomorphic processes. This method is particularly useful for exploring inaccessible and dangerous areas, as well as for demonstrating landscape changes over time [12].

VR avatars have also been used to teach children about healthy eating. In a study (n=15) involving children from low-income families, a VR program improved their acceptance of healthy eating information and stimulated dialogue between parents and children [13].

The studies cover applications of VR in engineering (2), medical (6), design (1), pharmaceutical (1) and environmental education (1), as well as in patient care (1) and geovisualization(1).

Methodologies such as experimental (4), quasi-experimental(3) and comparative surveys(6), questionnaires(10), interviews(3), as well as methods for assessing satisfaction and effectiveness of training(7) were used for these studies.

The literature review shows that the use of virtual reality (VR) and related technologies helps to achieve the expected results, but no good practices were found in applying VR to the education of economics students.

3. System development

The content development sequence was carried out according to the Systems Development Life Cycle (SDLC), which consists of analysis, design, implementation, and evaluation phases. SDLC is one of the main development methods for computer systems and mobile devices [14]. The platform consists of two parts: the student game area and the teacher setting area.

1. Analysis of content development needs

In order to introduce students to new innovative learning spaces and to address the challenges of applying contemporary teaching/learning methods in the social sciences, the following objectives were set:

- Digitizing the study content by using Virtual reality platform;
- To create modern content to supplement traditional educational methods with the latest technologies.
- To encourage creativity and create opportunities for users to get involved in the content creation process themselves.

The main objective of the project was to address challenges in applying modern teaching and learning methods in social sciences by digitizing study content through a virtual reality platform aimed at enhancing students' critical thinking, communication, collaboration, and creativity skills.

During the COVID-19 pandemic, simulation proved to be a valuable educational method [15]. The interactive nature of game-based learning tools increases student engagement and supports experience-based learning, as described in constructivist theory [16]. VR-based simulation games are therefore seen as an effective method to meet the demands of virtual learning.

2. Design content

The virtual reality platform to be developed was to cover 9 economic topics, which were distributed among the universities: I Lithuania: 1. Cartel, 2. Collusion, 3. Insurance management, 4. Investment management, 5. Promotion; II Poland: 6. Leadership, 7. Motivation; III Latvia: 8. Management, 9. Economics

University lecturers used the created template to describe the game scenarios: System action, Player (student) action, Lecturer action. The scenarios were analyzed for content validity by partners across each country, including academic researchers and one professor in the field of economics.

3. Implementation

By summarizing the 9 case scenarios, a systematic Game sequence for the game and the teacher setting areas (Picture 1) was created.

To implement the scenarios, VR developers UAB „Iron cat" (Lithuania) created a game platform using virtual room content. Picture 2 shows the user interface (UI) design of the scenario-based VR content, coordinated with platform developers and university experts.

4. Subjective assessment of usability by students

The general characteristics of the study participants were obtained from their responses to questions about experiences with IT for learning and non-learning purposes, included 4 questions: 1. IT is my work tool; 2. I use IT in my free time; 3. I use VR technology; 4. I play computer games. Questions were rated on a five-point Likert scale ranging from (1) I don't use it, to (5) Every day.

The tool for evaluating the usability of the developed VR-based gamified educational content were designed for this study considering of the VR content usability assessment tools developed by Jeong et al [17] and Keller's [18] ARCS (attention, relevance, confidence, and satisfaction) Model of Motivational Design. A post-experiment questionnaire (Impressions after the experiment) was created (Table 1).

Researchers developed an additional questionnaire to record interface defects (Event diary), consisting of 3 questions: 1. Defect description (briefly describe the problem); 2. Provide a link to the window (if applicable) where you found the defect; 3. How did the problem start? What steps were taken before the problem occurred or the data was entered? If the message is unclear. What is unclear? If the button name is unclear. What kind? I didn't know what to do. Comment on the found defect.

Questions were rated on a five-point Likert scale ranging from (1) Not at all, to (5) Very high degree.

Respondents also provided answers to open questions: 1. Did you encounter difficulties, surprises?, 2. What did you like the most?, 3. What did you dislike the most?, 4. What is missing in the case?.

Testing took place in two phases. After summarizing the first phases results of the questionnaires, a list of errors and comments was created. Design errors and comments were discussed with the VR developers' team and a "UI Protocol" document was created. Based on this, the system was further developed, and a second phase of testing was carried out in a similar way.

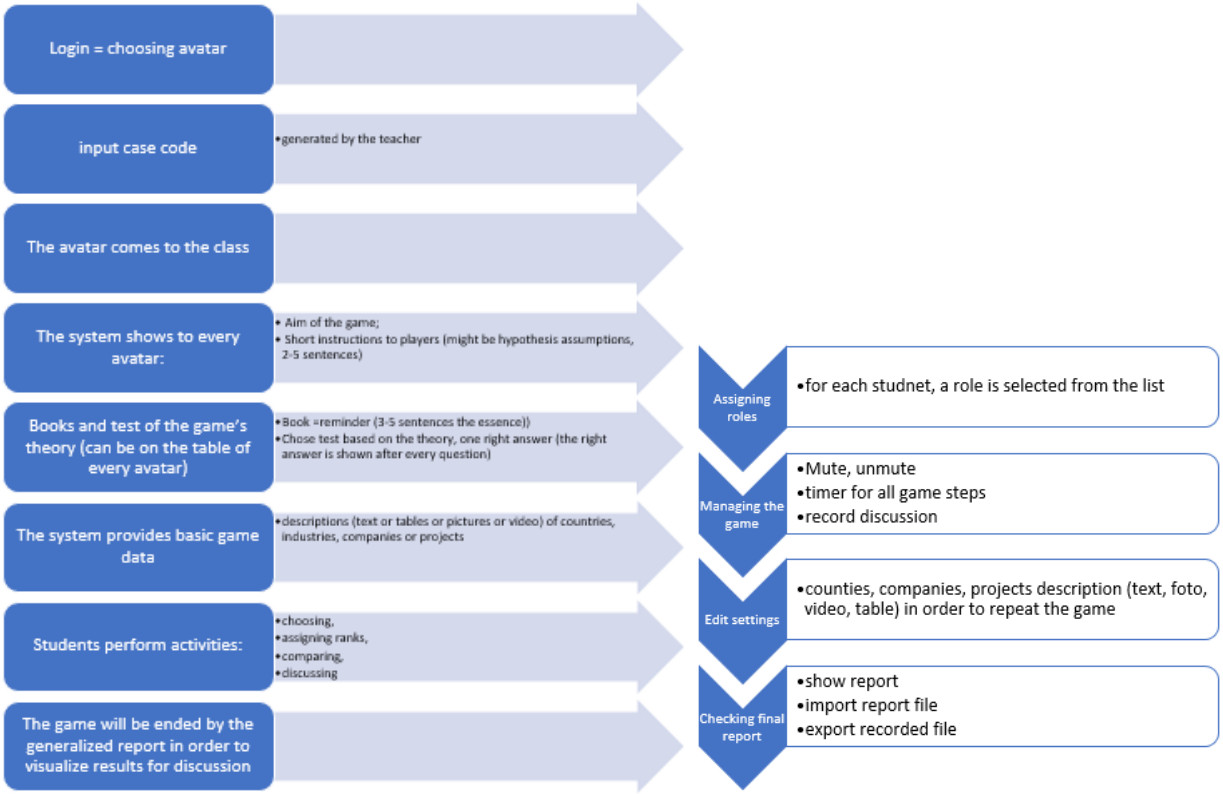

Figure 1. Game and Teacher setting areas

Figure 2. Examples of the main screens in tools for economics students

Table 1. Details of the post-experiment questionnaire filled in by students.

	Questions	Variables	Answer
Q1	The tool allows faster absorbing of educational material	Confidence	(1) Not at all (2) Small Degree (3) Moderate Degree (4) High Degree (5) Very High Degree
Q2	I liked everything	Satisfaction	
Q3	I am impressed by the game	Satisfaction	
Q4	It is useful tool for absorbing a new economic topic	Relevance	
Q5	I feel comfortable wearing 3D glasses	Satisfaction	
Q6	I feel tired wearing 3D glasses	Satisfaction	
Q7	Information is clearly laid out in the system	Attention	
Q8	Do you want to repeat the same game?	Relevance	1~5
Q9	Do you want to repeat the game with another information?	Relevance	1~5
Q10	How often do you want to play such games during lectures?	Confidence	(5) Every lecture (4) Once a week (3) Once a month (2) Once per subject semester (1) Don't use it
Q11	Can you explain the main things of the subject after the game?	Relevance	1~5
Q12	Do you recommend such studies to your friends?	Satisfaction	1~5

In total, 91 students participated in this study, 67 students in the first phase, and 24 in the second phase.

4. Quality assessment

The suitability of the created educational content for use by economics students, attention, relevance, confidence, and satisfaction with the content were assessed (Table 2).

Picture 3 show how the training content of the VR tool has quality assessment. 56%/75% (pfase1/pfase2) agreed or partly agreed that the tool allows faster absorbing of educational material, and it is useful tool for absorbing a new economic topic (76%/75%), and they partly can or partly can't explain the main things of the subject after the game (63%/71%).

About half of all students agree or partly agree to repeat this game. In phase 1, students indicated that they want to use once a week (40%), while in phase 2, 29% each indicated that they want to use once a week or once a month. 61%/79% want or partly want to repeat the game with other information. Students noted that the need to fill in the tables during games using 3D glasses is tiring on the eyes and not comfortable, so over 50% of students did not provide their opinion.

59%/63% agreed or partly agreed that they like everything about the system, 68%/77% impressed by the game.

Table 2. Analysis of the VR usability based on a subjective assessment by students.

		Phase 1 (n=67)		**Phase 2 (n=24)**	
Category		Mean	SD	Mean	SD
Attention	Q7	3,471	0,087	3,500	0,096
Satisfaction	Q2	3,574	0,293	3,458	0,021
	Q3	3,603	0,351	3,708	0,469
	Q5	2,324	-2,206	2,000	-2,590
	Q6	2,132	-2,589	1,958	-2,077
	Q12	3,561	0,267	3,458	0,322
Confidence	Q1	3,353	-0,148	3,500	0,096
	Q10	3,391	-0,080	2,947	-0,495
Relevance	Q4	4,029	1,204	3,833	0,693
	Q8	3,169	-0,500	3,458	0,322
	Q9	3,754	0,667	4,000	1,189
	Q11	3,121	-0,629	3,261	0,006

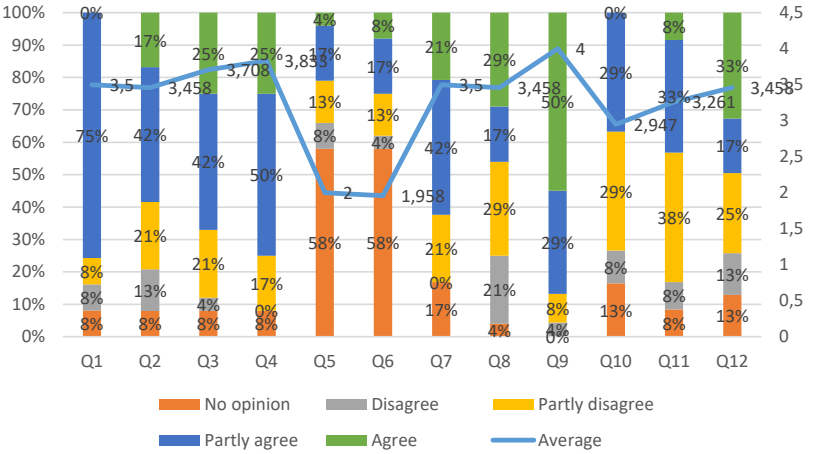

Figure 3. Analysis of the usability based on a subjective assessment by students Phase 2.

As a result of evaluating how much the content is related to practical learning skills or acquired goals, the score was 3.64 out of 5 points, the highest content usability evaluation items.

The degree of attention to the developed contents were evaluated as 3.5 points out of 5 points. Attention during learning is an important factor in achieving the learning goal, and gamification of the content allows to maintain and attract attention. The degree of confidence after applying the content was 3.37 (1 phase) out of 5 points. In phase 1, 47% indicated that they wanted to play such games every lecture or once a week, while in phase 2 more (50%) indicated that they wanted to play once a week or once a month, which is less frequent use.

Overall satisfaction with the content was 3.04 (out of 5 points). For the questions 'I feel comfortable wearing 3D glasses' and 'I feel tired wearing 3D glasses' over 50% of respondents in each phase did not give an opinion. Due to the abundance of tables in the game, respondents preferred to use the desktop version of the system rather than VR (Picture 4).

VR technology is effective in increasing student engagement and promoting independent learning.

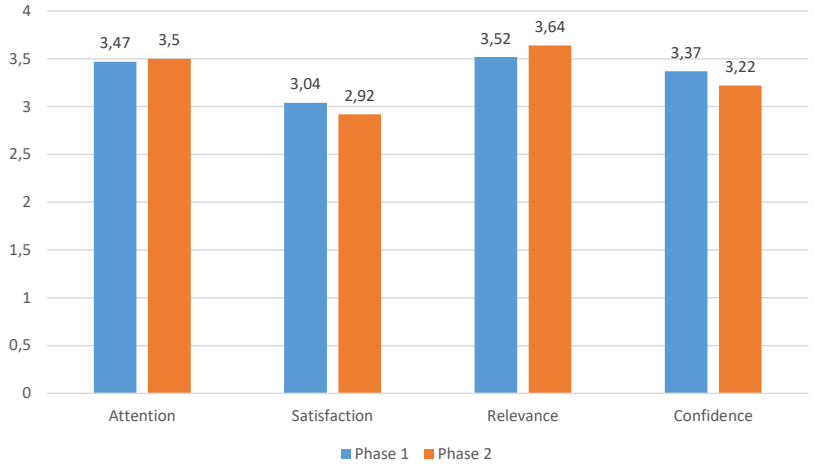

Figure 4. Usability Evaluation of Developed Educational Content

5. Conclusion

This study was carried out to investigate the usability of a VR-based development tool and the relevance of the content for economics students. After applying the VR content developed in this project, the economics students rated the relevance and usability of the tool. VR tools and content are effective in enhancing students' critical thinking, communication, collaboration and creativity skills, as the created material is an impact for updated subject content products in higher education programs, which can use the platform for substantiation, simulating various practical areas of economics, finance, marketing, management, etc. situations and tasks. Students can solve various real practical situations that cannot be understood without the help of reality.

This tool applies to a gamification element, i.e. the awarding of points to measure performance and determine the winner. However, gamification strategies were limited due to the specific nature of the economics subject, where there are many tables and calculations.

The teaching scenarios created in the tool can also be used to support students' learning in other subjects. The development of new teaching materials for other subjects will allow the tool to be used more widely.

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