Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation

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Preface

This research and the subsequent paper are the result of my masters program as a Game and Media Technology student at the University of Utrecht. I have worked on developing the prototype software and on conducting the research from March to December 2023 in order to gain the 40 ECTS credits needed to graduate. I am also Lead Software Engineer and partial owner of Changefied, the company that develops the application. The application was developed in collaboration with the College of Technology in Rotterdam and was prototyped and tested at the Practical School in Hoorn prior to conducting the study. The research process was guided by Prof. dr. Remco Veltkamp, professor of the Game and Media Technology master at the Faculty of Science of the University of Utrecht.

Abstract

Immersive Virtual Reality (IVR) has become a powerful tool in education, offering a natural and engaging learning experience. This thesis presents a case study conducted at the College of Technology in Rotterdam, focusing on a Secondary Vocational Education Level 2 course teaching computer assembly. For this course, Virtual TechLab was developed, an IVR application by Changefied, aiming to enhance computer assembly skills. Recognizing the importance of collaboration in learning, especially in IVR environments, this research investigates the impact of multiplayer capabilities in Educational Virtual Reality Games (EVRGs) on learning efficiency and student motivation.

Data collection involves two groups, one group that plays the game individually and a group that is allowed to play the game with two-player symmetrical collaboration. The research evaluates learning outcomes through a standardized exam and subjective metrics using a questionnaire based on the Cognitive Affective Model of Immersive Learning (CAMIL). The hypotheses test the significance of collaboration in improving motivation and learning efficiency.

Motivation levels, as measured by the questionnaire, did not show a significant increase between the individual group and their collaborating peers.

Comparing exam scores between the two groups did not yield a significant difference. However, students that were able to collaborate reported significantly enhanced factual and procedural knowledge on the questionnaire as well as significantly improved levels of self-efficacy.

Patterns in the results suggest that further research with larger sample size could allow for more conclusive results.

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1 Introduction

Immersive Virtual Reality (IVR) has gained significant popularity since its inception [18], and for good reason. IVR is a technology that allows users to interact with a digital environment more naturally than a game on a screen would [9]. When used for educational purposes, this allows for a more natural and immersive learning experience. Using IVR within education has not only been shown to enhance student performance [23], but also increases student enjoyment because of the gamified approach IVR education offers [4, 10]. This improves student performance even further [20]. This technology is already getting widespread use in educating medical students [6] and has increasingly been adopted in other fields of education.

The 'Techniek college' (College of Technology) in Rotterdam is the largest technical vocational school in the region of Rotterdam-Rijnmond. They offer many different educations with varying courses. For this case study, we focus on the Secondary Vocational Education Level 2 course that teaches students how to assemble and disassemble computers. To assist in teaching this course, an IVR application is made.

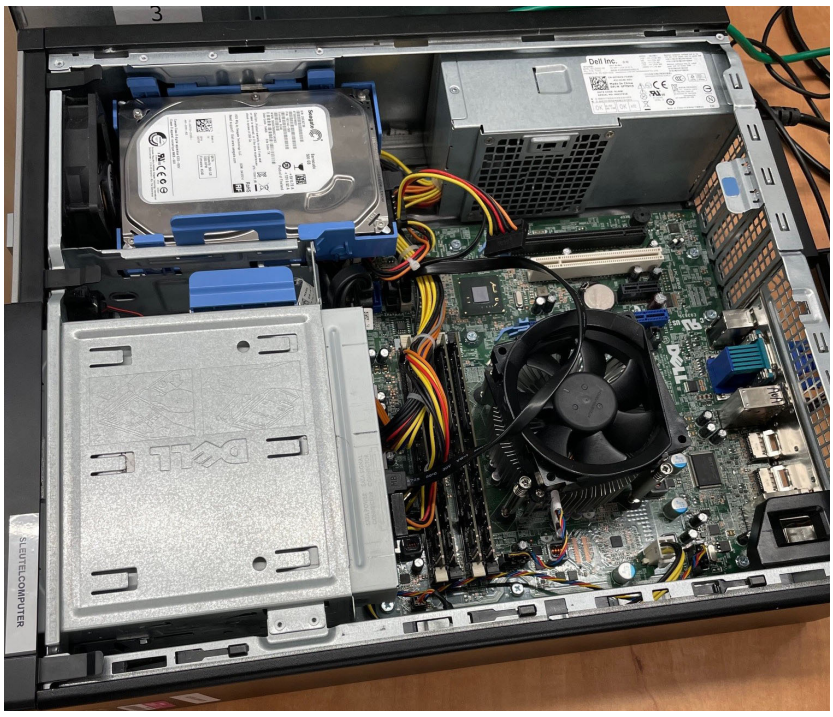


Figure 1: The inside of a computer

Changefied is a young and innovative company that focuses on developing gamified solutions for problems within the social domain by utilizing technology like IVR. It strives to create equal opportunities for everyone to learn, regardless of their background or abilities.

Changefied is developing Virtual TechLab, an IVR application that teaches its users computer assembly and disassembly skills. Due to the frequent manipulation of components and their delicate nature, there is a risk of accelerated wear and tear, as well as the possibility of component breakage resulting from a single mistake. Consequently, this necessitates the frequent replacement of computer parts, which is not only wasteful but also incurs substantial expenses. As a consequence, students are allotted only limited time for practice. Not only would an IVR application allow for almost unlimited practice. It would also allow for experiences that are completely off-limit to the students at the moment, like taking the processing unit out of the motherboard. Finally, theoretical information can be more easily interwoven with practical experience because an IVR application allows explaining things during practice.

To gain insight into the positive aspects of the existing teaching method that should be preserved during the transition to IVR, as well as identify areas that require improvement, an interview was conducted with René de Bruin, team leader of the Regional Practice Center of Rotterdam. The interview revealed that student collaboration is an integral part of the learning experience. However, it was observed that multiplayer functionalities are often missing from educational IVR experiences, with Oyelere et al. [18] showing only 4 out of the 31 reviewed Educational Virtual Reality Games (EVRGs) to contain multiplayer, despite evidence indicating that collaboration significantly enhances student motivation [13, 21] and learning outcomes [1].

Collaboration can be defined as the process of individuals or groups working together in a coordinated and cooperative manner to achieve a shared goal or complete a task. It often involves the sharing of knowledge, skills, resources, and ideas to create a synergy that enhances the overall effectiveness and efficiency of the work being undertaken. Collaboration encourages active engagement [19, 3] and allows for viewing a problem from multiple perspectives. Collaboration also improves communication skills [11], preparing students for real-world scenarios where collaboration and adaptability are essential. It differs from cooperation in the sense that in cooperation the individuals work together to each achieve their own goals while in collaboration the individuals work together to achieve a shared goal.

One probable cause for multiplayer collaboration not seeing more widespread use within EVRGs pertains to the increased production costs. Implementing real-time multiplayer capabilities into a game greatly increases complexity, thereby heightening development difficulty which subsequently increases production costs. It is therefore important to have a better understanding of the effectiveness

of multiplayer collaboration in similar applications allowing a more informed assessment of the justifiability of the investment.

This thesis aims to explore the significance of collaboration within EVRGs, utilizing the case study of the Virtual TechLab application. The study compares student performance under two conditions: with the Virtual Reality (VR) application solely in single-player mode, and with the VR application while facilitating multiplayer collaboration in groups of two. The objective of this study is to address the following question:

> *RQ*: *What is the impact of two-person symmetric collaboration on student motivation and learning efficiency in a virtual reality simulation?*

The research question consists of two sub-questions:

> SQ_1: *What is the impact of two-person symmetric collaboration on student motivation in a virtual reality simulation?*

and

> SQ_2: *What is the impact of two-person symmetric collaboration on learning efficiency in a virtual reality simulation?*

2 Related work

Cruz-Neira et al. [5] present an editorial introduction to a special issue of the "Multimodal Technologies and Interaction" journal, with a primary focus on VR and games. The introduction delves into the history and definition of VR, emphasizing its potential in creating immersive and interactive experiences within synthetic worlds. The introduction further explores the diverse applications and benefits of VR and games across various fields and domains. These include, entertainment, education, training, simulation, cultural heritage, and health. Current research trends and challenges within the realm of VR and games are also discussed. These encompass aspects such as the degree of immersion, the optimal amalgamation of technologies, user engagement, satisfaction, learning outcomes, and the ethical and social implications. Lastly, the introduction provides an overview of the seven papers included in the special issue. These papers span a range of topics, including VR exploration, VR learning environments, VR game mechanics, VR motion data, VR user experience, VR cybersickness, and VR storytelling.

Hamilton et al. [7] performed a literature review that suggests that IVR can enhance learning in about half of cognitive studies, particularly in complex problems requiring spatial understanding and visualization. While some studies found no significant benefit, very few had negative effects on learning outcomes. However, the use of traditional assessment methods, short exposure times,

and isolated interventions may limit IVR's effectiveness. It is promising for procedural tasks, with evidence of successful transfer to real-world scenarios. Additionally, IVR has potential for cost-effective and safe practice. The review also highlights the need for more research in affective behavioral change using IVR.

Hansen et al. [8] explore a similar topic to the current study. They also compare two groups of players playing an EVRG. One of the groups play the game individually while the other group plays the game in groups of two. The two-player version includes one player playing the VR game as usual with a second player outside of VR with the needed materials printed on paper. This study shows that the questions related to a positive user experience scored significantly higher for the VR players in the two-player version compared the single-player version. Besides that, the questions related to annoyance scored significantly lower for the two-player version when compared to the single-player version. In contrast to the study by Hansen et al. [8], in the current study, both players have a symmetric role in the game. They are both able to manipulate the environment together to solve problems. The current study also explores the differences in player performance on top of user satisfaction and enjoyment.

Vargas [22] documents the development and testing of a multiplayer VR game called CLEVR, which teaches students the inner workings of a biological cell. This game also has an asymmetrical approach to collaborative learning. The paper explains how the distribution of information is used to incentivize collaboration between the roles. Furthermore, the paper mentions how the ability to manipulate the environment of the other player has a crucial role on creating collaborative engagement. It also showed that the prior relationship between the players can have a significant role on the efficiency with which the players can collaborate.

Zhao et al. [24] attempt to illuminate the query on whether it is feasible and beneficial to replace physical practice of manufacturing tasks with an IVR simulation. The paper documents the process of implementing the IVR application and discusses the challenges and opportunities that were faced during development. The results, however, were inconclusive due to the limited scope of the research.

Manninen [16] explores the ways in which players interact in the first person shooter Counter-Strike. The observation is made that players felt very satisfied after networking through the game. It was also noted that suspension of disbelief reduces the necessity for realistic manners of communication. Players will communicate through whichever means they are provided with. Lastly, it is noted that players in close proximity to each other prefer to communicate verbally, outside the mechanics of the game.

McGrenere [17] performed a literature study on the issues involved in the design of educational electronic multi-player games. They observed that many children and adolescents are highly motivated to play video games and that this motivation

can be utilized for educational purposes. They state, however, that previous attempts at this have had mixed results. It is also concluded that most research is done on single player games and that multi-player games are not very well researched. They claim that, even though cooperation in traditional education has been proven effective time and time again, there is still almost no research on multi-player educational games.

Bogusevschi et al. [2] analysed the user experience and usability of a 3D immersive computer-based Physics educational application. They used virtual environments to teach secondary school students physics concepts related to the water cycle. They saw significant improvements in performance of students that used the application when compared to the control group as well as high user enjoyment.

Lawson [12] investigates in what manner cooperation can be made more effective in education. It states that cooperation involves talk, action, and reflection among individuals and can lead to a community of learners. Furthermore, it is noted that collaboration plays a crucial role in learning. Discussing and sharing ideas can lead to increased understanding of the subject matter and allows for new perspectives to be found and explored.

Makransky and Petersen [15] build upon the Cognitive Affective Model of Immersive Learning (CAMIL)[14] to construct a model that identifies how technological features, social affordances, and pedagogical techniques positively impact several factors that are inherently distinct in extended reality–supported collaborative learning (XRCL) when comparing it to traditional collaboration. These factors are social presence, physical presence, body ownership, and agency. According to their model, this is a consequence of the fact that XRCL provides a higher level of sensory fidelity, interactivity, and embodiment. These can create stronger illusions of being and acting in a virtual environment with others.

Collectively, the related works demonstrate the potential benefits of gamification[17] and IVR[7, 8, 2, 15]. These benefits range from increased engagement and motivation to enhanced learning outcomes, especially in subjects requiring spatial understanding and visualization. Additionally, these works highlight how students can benefit from collaboration within an educational context[12] by leading to increased understanding and by allowing for new perspectives.

These benefits form the rationale for investigating the effect of the combination of these concept in a multiplayer EVRG. The related works include several examples of this[8, 22], however all of them are asymmetrical, with one player in the virtual environment and the other player outside of the virtual environment assisting the first player. This leads to the question of how players are affected by a symmetrical approach to collaboration, in which both player are present in the same virtual environment and can see and interact with each other, which is more similar to how students would normally collaborate in a classroom.

Additionally, these works help guide the development of the VR prototype by showing how players prefer to communicate in games and how this can affect their experience.[16]

3 Methodology

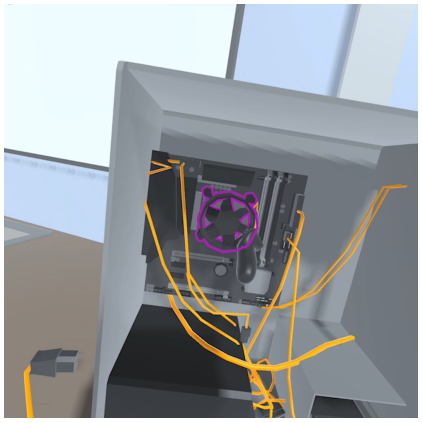
3.1 Application description

This case study focuses on a custom-made VR simulation comprising ten levels designed to facilitate computer assembly and disassembly practice for students. The students play the game on Meta Quest 2 headsets, providing 6 degrees of freedom for both the headset and controllers. The school has eight VR headsets available at the moment. At the same time, the teacher has a tablet with a companion app. This app can be used to look at what the students are seeing in VR and to perform operations such as starting a level or connecting two students for a multiplayer session.

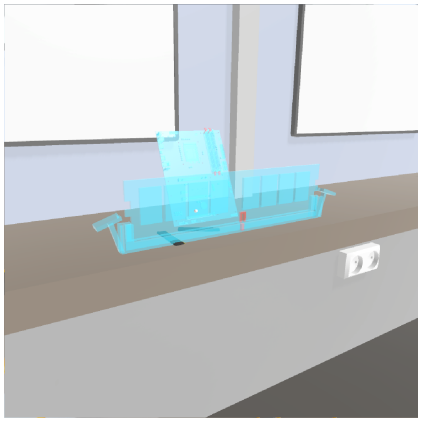
Figure 2: Companion app with two connected players and a single player

The application begins with a tutorial level, imparting the students with the knowledge on how to operate the application. This first level is always played individually. The second level teaches the students basic knowledge about safety measures when working with computers. Subsequent levels progressively introduce specific computer components, discussing their various types, and guiding the players through the process of assembling these components into a computer.

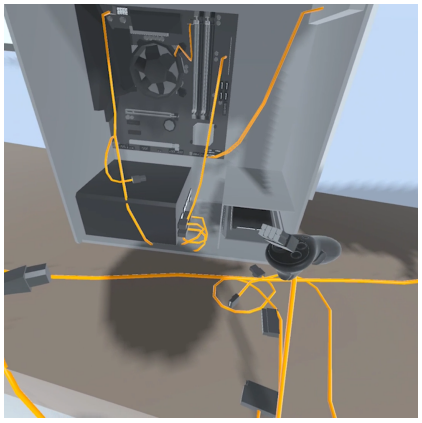
The simulation offers an immersive, physically simulated environment, allowing players to navigate freely, interact with computer components, and collaborate with up to two players in the same virtual environment.



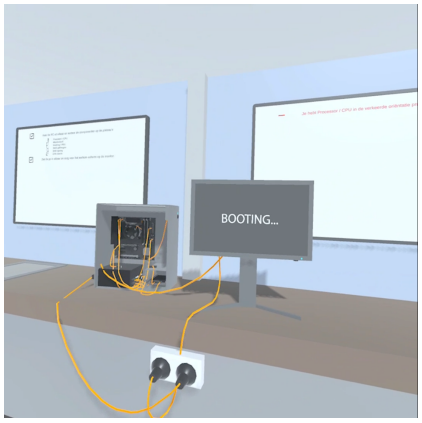
(a) Player selects the cooler to be able to pick it up.



(b) Animation showing how to install a RAM module.



(c) Player inspecting an 8-pin connector.



(d) Computer has been assembled and is now booting.

The VR application specifically contains the following parts:

- A modular system that allows for manipulating parts by picking them up, rotating and moving them and connecting them to other parts.
- Multiplayer functionality, allowing two players to be in the same environment and manipulating the components together.
- A companion app that allows a teacher or supervisor to watch what the players are doing and start a level.
- A tutorial teaching the basic controls.
- A level on computer assembly safety.
- A level on the power supply unit.
- A level on the motherboard.
- A level on the processor.
- A level on the cooler, including cooling paste.
- A level on random access memory.
- A level on data storage drives.
- A level on the graphics processing unit.
- A level for finishing up and turning the pc on.
- Syncing the level state and voice overs during online play.
- The ability to connect two players together from the companion app.
- Syncing the game state for players that join during a level.

All levels include the following:

- voice-overs explaining information about the component.
- Animations that add a visual element to support the explanations in the voice-over.
- The ability for the player to perform the actions needed to assemble the component.
- Step-by-step guidance during the assembly process.
- The ability to adapt the level and voice overs to the player doing something different than what they should do, using an internal flowchart.

To give an impression of the application, an edited video of the demonstration level has been made. The audio in the video has been translated from Dutch to English.

`https://www.youtube.com/watch?v=TODo1d28rm8&ab_channel=Changefied`

3.2 Data collection

Participants in this study are be divided into two disjoint groups. Both groups are taught the course on how to assemble computers using conventional didactic methods in addition to having access to the VR simulation. However, the first group is restricted to using the application individually, while the second group is able to leverage the two-person multiplayer feature, facilitating collaborative learning.

The students are from three different classes; class A, class B and class C. Class A contains 13 students, class B has 8 students and class C has 20 students. Class A and B will play the game individually while class C will be allowed to cooperate within the game.

8 VR headsets are available for testing. Each session, up to 8 students will be taken from a class, they will play the game for 30 minutes, after which they will return to the class and the next set of up to 8 students will play the game. Each class will play 3 sessions divided over 3 weeks. In total, this allows each student to play the game for up to 90 minutes.

Since participation is voluntary, it is not possible to know exactly how many students will attend each session. To make sure the students had a chance to get a good feel for the game, only results from students that attended at least two sessions will be used.

Figure 4: Classroom with VR gear ready for the students

To gauge the impact on learning efficiency, all students undergo a standardized exam upon completing the course, graded on a scale of 1.0 to 10.0. This exam serves as the objective metric for assessing student performance between the two groups.

Prior to the examination, each student is required to complete a questionnaire, which can be found in the appendix. This questionnaire serves as the subjective metric and is founded on The Cognitive Affective Model of Immersive Learning (CAMIL) developed by Makransky and Petersen [14]. The CAMIL framework is a theoretical model that describes the dynamics of learning in IVR. It delineates how various technological factors impact the main psychological affordances of IVR, presense and agency, and elucidates how these affordances, in turn, influence the affective and cognitive factors, ultimately affecting the different learning outcomes. Each question in the questionnaire is designed to gain insight on how the multiplayer collaboration influences each of the different IVR affordances, Affective & cognitive factors as well as learning outcomes. Table 1 details the association between each question and its corresponding aspect within the CAMIL framework. Each of the questions will be answered with an integer value ranging from 1 to 10.

Questions 8, 9 and 10 can be specifically employed to address the research query pertaining to student motivation, while questions 17 and 18, in conjunction with the examination results, can offer insights into the impact on learning efficiency. The remaining questions can give an indication on how the different factors involved in learning in IVR are affected. This analysis aims to lead to deeper understanding of how and why the learning outcomes are impacted by the collaborative features.

Question	**Aspect of the CAMIL**
1, 2	Presence
3, 4	Agency
5, 6, 7	Interest
8, 9, 10	Motivation
11, 12	Self-efficacy
13	Embodiment
14, 15	Cognitive load
16	Self-regulation
17	Factual knowledge
18	Procedural knowledge

Table 1: Legend for the CAMIL aspect of each question in the questionnaire

3.3 Hypothesis

We formulate the null hypotheses ($H1_0$ and $H2_0$) as a foundation for our statistical analyses, representing the default assumption that there is no significant increase in motivation and learning efficiency between students who collaborate and those who work individually using the application:

> $H1_0$: *Students allowed to collaborate will* ***not*** *exhibit increased levels of motivation compared to those who used the application individually.*

and

> $H2_0$: *Students allowed to collaborate will* ***not*** *exhibit increased learning efficiency compared to those who used the application individually.*

The previously mentioned literature forms the foundation for proposing alternative hypotheses ($H1_A$ and $H2_A$) that state that students that are allowed to collaborate will show improved motivation and learning rates:

> $H1_A$: *Students allowed to collaborate will exhibit increased levels of motivation compared to those who used the application individually.*

and

> $H2_A$: *Students allowed to collaborate will exhibit increased learning efficiency compared to those who used the application individually.*

3.4 Analysis

In order to analyse the exam results, a one-tailed t-test is used as opposed to a two-tailed t-test because this results in a higher statistical power. Since the sample count for this research is limited it is essential to optimize the statistical power as much as possible. However, there are some criterion that must be fulfilled in order to be eligible for a one-tailed t-test.

The first criteria is that the data must somewhat resemble a normal distribution. Exam grades are usually believed to be relatively close to normal distribution.

The second criteria is independence of observations. The students take the exam simultaneously and individually. Therefore, the grade of one student does not affect the grade of another student.

The last criteria is that the alternative hypothesis has to indicate a direction that should be justified by a strong theoretical rationale. Our alternative hypothesis anticipates an improvement in student performance. This is backed up by the previously mentioned research that states that collaboration improves learning efficiency [1, 12] and active engagement [19, 3].

Given that each question in the questionnaire is answered with a numerical value ranging from 1 to 10, a similar analysis to that of the exam results may be performed. For the same rationale justifying the utilization of a one-tailed t-test for comparing exam results, a one-tailed t-test is also applicable to compare the results of the questions pertaining to learning efficiency.

Since the literature also indicates that student motivation is improved by collaboration [13, 21], it would also be preferred to analyse the results pertaining to motivation with one-tailed t-tests. Since it is not yet clear how any of the other factors are influenced by collaboration, the analysis of the results of the other questions will be performed using two-tailed t-tests. Table 2 summarizes which t-test is used to analyse each result.

	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**Q18**	**Exam**
Tails in T-test	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2	1	1	1

Table 2: Overview of whether each result will be analysed using a one-tailed or two-tailed t-test

All of the tests are performed at the standard significance level of 0.05. The t-test calculations are performed in Excel using the $T.TEST$ function.

3.5 Ethical considerations

Prior to commencing the research, an ethics quick scan was conducted by the University of Utrecht to assess the ethical implications of the study. The results of the quick scan can be found in the appendix.

The quick scan highlighted two crucial ethical considerations that require careful attention. The first concerns a possible conflict of interest due to my partial ownership in the company for which the research is conducted. Consequently, there exists a potential for bias towards favorable outcomes in the course of my experiments. To address this concern, I am committed to implementing robust measures to mitigate any bias.

To ensure impartiality, I maintain regular communication with my impartial supervisor throughout the research. Additionally, I strive to employ objective measurements wherever feasible, particularly in areas where a favorable outcome may be desired. Where subjective conclusions are necessary, I transparently disclose the underlying data and approach the conclusions with honesty, always mindful of this potential bias. By diligently combining these efforts, I am confident in my ability to approach the research in a sincere and unbiased manner.

The second ethical consideration pertains to involving minors under the age of eighteen in the study. Adhering to ethical standards, all participating students are presented with an information sheet and a consent form to ensure voluntary participation. Additionally, parents or legal guardians of minors must also provide explicit consent through the means of the consent form. These consent forms and information sheets were provided in both Dutch and English. The English version of the information sheets and consent forms for minors and for adults can all be found in the appendix.

4 Results

From the single-player group, ten exam results and eleven questionnaires were gathered. From the multiplayer group, nine exam results and seven questionnaires were gathered.

The results of each question in the questionnaire are summarized in Table 3 and in Figure 5.

	Singleplayer		Multiplayer	
	Mean	**STD**	**Mean**	**STD**
Q1	7.9	1.8	7.7	1.3
Q2	7.6	1.1	7.1	1.1
Q3	8.1	1.7	8.4	1.1
Q4	7.2	1.6	8.0	0.8
Q5	8.4	2.1	9.0	0.8
Q6	7.5	2.1	8.6	1.4
Q7	8.7	0.9	8.9	1.1
Q8	8.6	1.9	8.7	1.4
Q9	8.2	1.8	9.3	1.0
Q10	8.4	1.6	8.9	1.2
Q11	6.8	1.6	9.3	1.0
Q12	8.6	1.3	9.0	1.0
Q13	6.4	1.2	7.7	1.7
Q14	5.2	1.9	5.7	2.6
Q15	5.2	2.6	5.0	3.2
Q16	5.0	2.5	4.9	3.4
Q17	6.7	1.7	8.7	1.1
Q18	7.0	1.7	8.6	1.4
Exam	7.7	1.8	8.0	1.1

Table 3: Results questionnaire and exam

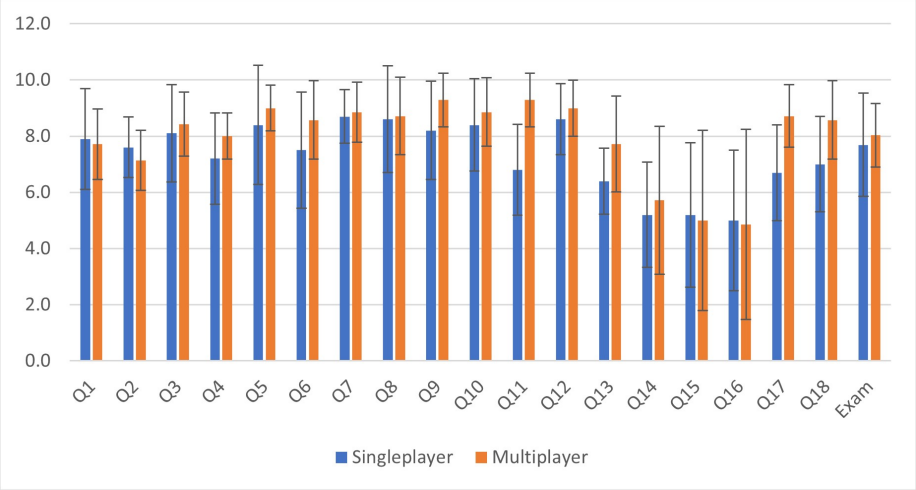


Figure 5: Results questionnaire and exam ($Mean \pm STD$)

4.1 Learning outcomes

One-tailed t-tests were conducted to compare the results related to learning efficiency. The findings reveal that the students that were permitted to collaborate did not achieve significantly higher scores on the exam compared to the students that were not allowed collaborate ($P_{Exam} = 0.320$, see Table 4). However, the collaborating students did report significantly more factual and procedural knowledge based on the questions in the questionnaire ($P_{Q17} = 0.008$, $P_{Q18} = 0.031$, see Table 4).

	Q17	**Q18**	**Exam**
p-value	**0.008**	**0.031**	0.320

Table 4: P-values of question 17 and 18 and the exam when comparing the single-player and multiplayer groups

4.2 Motivation

Similarly, one-tailed t-tests were conducted to compare the results related to motivation. The findings reveal that the students that were allowed to collaborate did not exhibit significantly higher levels of motivation when compared to the students that were not allowed to collaborate ($P_{Q8} = 0.447$, $P_{Q9} = 0.079$, $P_{Q10} = 0.271$, see Table 5).

	Q8	**Q9**	**Q10**
p-value	0.447	0.079	0.271

Table 5: P-values of question 8, 9 and 10 when comparing the single-player and multiplayer groups

4.3 Other IVR Affordances and Affective & Cognitive factors

The first observation is the relatively high standard deviation for questions 14, 15 and 16. This is attributed to the fact that all the other questions are asked positively, with a higher score being more favourable for the game, except for these questions. This has likely led to increased misinterpretations within these questions. Further investigation supports this idea given that there were several students that were very positive about the game, giving 9's and 10's across the board, that also gave a score of 9 or 10 on these questions. Consequently, results from these questions are considered unreliable and are therefore excluded from the analysis. Thus, cognitive load and self-regulation are omitted from consideration.

Finally, two-tailed t-tests were conducted to compare the results related to presence, agency, interest, self-efficacy and embodiment. The findings reveal

that the students that were allowed to collaborate reported that they were significantly better prepared for the exam because of the game when compared to the students that were not allowed to collaborate($P_{Q11} = 0.002$, see Table 6). The other aspects did not show a significant difference ($P_{Q1} = 0.817$, $P_{Q2} = 0.401$, $P_{Q3} = 0.667$, $P_{Q4} = 0.250$, $P_{Q5} = 0.490$, $P_{Q6} = 0.253$, $P_{Q7} = 0.754$, $P_{Q12} = 0.497$, $P_{Q13} = 0.078$, see Table 6).

	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q11**	**Q12**	**Q13**
p-value	0.817	0.401	0.667	0.250	0.490	0.253	0.754	**0.002**	0.497	0.078

Table 6: P-values of question 1-7, 11, 12 and 13 when comparing the single-player and multiplayer groups

5 Discussion and conclusion

Given that none of the questions related to motivation showed significant improvement for the participants that were allowed to collaborate, the results do not give enough evidence to be able to reject $H1_0$.

$H2_0$, regarding learning efficiency, is a bit more ambiguous. The students that collaborated reported significantly higher scores on how well they felt prepared for the exam because of the game as well as on the questions related to how much knowledge they gained on computers and computer assembly because of the game, despite not actually scoring significantly higher on the exam. This could indicate that collaborating within the game improves self-efficacy, contributing to improved learning outcomes. Alternatively, increased self-efficacy gained from collaboration might boost confidence in subject knowledge without a commensurate improvement in exam performance.

Overall, the collaborating students report slightly higher scores across the various IVR Affordances, Affective & Cognitive Factors and Learning outcomes, with the exception of presence. Though most of these differences are not significant. This consistent yet non-significant pattern could indicate that the study lacks the statistical power necessary to prevent type 2 errors. A larger sample size would be required to determine whether this is the case.

This thesis gives insight into how collaboration affects the different aspects that influence learning efficiency. Even though they are not fully conclusive, the results point toward an improvement in learning efficiency when collaborating. This thesis will hopefully spark the interest of other researchers to dive deeper into this subject matter and might eventually lead to more widespread adoption of such features in educational games, potentially improving the quality of gamified education in general. While the case study focuses on computer assembly, the results could potentially benefit other educational domains as well.

6 Future work

The current research only has a very limited scope, with limited participants and limited time for each participant to experience the game. Follow-up research could include a larger sample size with longer exposure to the game, for example during the entire course. This could lead to increased statistical power for more robust and generalizable results.

A follow-up study could be performed to gain insight into how cognitive load and self-regulation are affected by collaboration in order to get a more complete understanding of how collaboration might improve learning rates within EVRGs.

Additionally, a longitudinal study could be performed to track the progress of students who experienced a multiplayer EVRG. The study could assess whether the benefits observed in the short term are sustained over an extended period and whether they lead to enhanced real-world skills.

This research only looks into assembling computers as a case study. There are many more use cases where IVR games could be used to teach procedural skills and factual knowledge. It is essential to explore this space further and perform similar research on these other skills in order to gain insight on the broader concept of collaboration in EVRGs.

This study compares two-player asymmetrical collaboration against no collaboration, however there are many different ways to collaborate. Future research could compare different group sizes against each other. A comparison between the effectiveness of asymmetrical and symmetrical collaboration could also be made. Finally, a study could analyse the effect of forced collaboration, for example by partially hiding certain information to each of the players, on player enjoyment and learning rates.

Future research could involve a cost-benefit analysis to compare the benefits of multiplayer cooperation functionality within EVRGs against the additional costs that come from implementing such functionalities.

7 Acknowledgements

I extend my deepest gratitude to René de Bruin, whose unwavering support and facilitation were instrumental throughout this study. René's generosity in providing access to the school's hardware, classrooms, and his valuable time significantly contributed to the successful completion of this research. His assistance in organizing various aspects of the study has been invaluable, and I am truly appreciative of his commitment to the project.

I am indebted to Remco Veltkamp for his supervision and guidance throughout the research process. Remco's expertise and insights steered me in the right

direction and has been an invaluable asset, and I am grateful for the opportunity to work under his guidance.

A heartfelt thank you goes out to the students who actively participated in the study. Their willingness to engage with the research process provided essential data and insights, without which this study would not have been possible.

I extend my appreciation to my colleagues who supported and enabled the execution of this study. Their cooperation, encouragement, and assistance in developing the prototype software were vital to the success of the project.

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Questionnaire students techniekcollege (translated from Dutch)

First name:

Last name:

class:

1. To what degree did you feel like you were 'inside' the virtual environment?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

2. How real did the virtual environment seem to you?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

3. To what degree did you feel in control of the game?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

4. To what degree were you able to influence the virtual environment?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

5. How interesting was the content of the game?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

6. Did playing the game increase your interest in the course?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

7. Would you like to play the game again in the future (for example, if new levels are added)?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

8. Did you enjoy playing the game?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

9. Did playing the game make it more enjoyable for you to attend class?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

10. How motivated were you to learn while playing the game?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

11. Are you better prepared for the exam after playing the game compared to if you would not have played it?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

12. How well did you have control over the tasks you had to perform in the game?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

13. To what extent did it feel like you were the virtual character in the game?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

14. How much effort did you have to put into thinking while playing the game?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

15. Did you have to think about many things at once while playing the game?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

16. How difficult was it to stay focused on the explanation?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

17. Did playing the game improve your knowledge of computers and computer components?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

18. Did playing the game improve your knowledge of assembling computers?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐

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Research Participant Information Sheet

"Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation"

10-2023

1. Introduction

You have been asked to participate in a scientific study regarding the impact of collaboration in educational VR simulation games. The research will take place at the Techniekcollege Rotterdam.

2. What is the background and purpose of this study?

The Techniekcollege aims to incorporate the Virtual Reality (VR) game VR TechLab into the "Hardware for ICT Support" curriculum. In this game, you will learn about the various components of a computer, considerations when purchasing these components, and how to install them into a computer. The game also allows two students to play the same level simultaneously in the same virtual environment.

The purpose of this research is to determine the effect of this collaboration on learning outcomes, motivation, and overall satisfaction.

The game is produced by and is the property of Changefied.

3. Who will carry out the study?

The research will be conducted by Erik Welling as part of his master's thesis at the University of Utrecht, under the supervision of Remco Veltkamp and Wolfgang Huerst. Additionally, René de Bruin will be present during the research to provide support and guidance.

4. How will the study be carried out?

Throughout the remainder of the block, you will play the VR game in support of your lessons. You will play the game divided into three to four sessions. Each session will last for half an hour. Half of the students will play the game exclusively on their own, while the other half will have the opportunity to play the levels together. No data will be collected during gameplay.

Erik Welling and/or René de Bruin will be available to assist with technical or content-related questions.

Just before the end of the block, you will be asked to fill out a questionnaire about your experience with the game. This questionnaire will not be graded and will not impact your grade; it is solely for data collection purposes.

Following this, you will take the exam just as you would have taken if you had not played the game. This exam will count toward your grade and will also be used for research purposes.

5. What will we do with your data?

The results of the questionnaire and the exam will be collected and stored on a password-protected laptop. The data will be kept confidential, with only Erik Welling, Remco Veltkamp,

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Wolfgang Huerst, and René de Bruin having access to this data. The data will be retained in a personally identifiable form for a maximum of six months and will then be fully anonymized. The anonymized data may be mentioned in research papers for transparency and potential follow-up studies. This research is conducted as Erik Welling's thesis project at the University of Utrecht during his internship at Changefied. Apart from Erik Welling, Changefied will not have access to personally identifiable data.

6. What are your rights?

Participation in the research is voluntary. We will only collect your data with your consent, which you can provide through the consent form. If you decide not to participate in the research, you don't need to do anything. You are not required to sign anything or provide a reason for not participating. Your decision will not affect your grade or the course.

You have the right to withdraw your consent at any time, including during and after the research. We will not collect any further data from you from that point, and all data collected up to that point will be deleted. However, we are not required to delete processed, anonymized data if you choose to withdraw from the study afterward.

7. Approval of this study

This research has been approved by the Research Institute of Information and Computing Sciences based on the Ethical Quick Scan. If you have any complaints about how this research is conducted, you can send an email to ics-ethics@uu.nl. If you have questions or complaints about the way your personal data is used or processed, you can send an email to privacy-beta@uu.nl. They can assist you with questions and complaints about your personal data and your rights under the GDPR. For more details on our rights and obligations regarding personal data, see the University's privacy statement: www.uu.nl/en/organisation/privacy.

8. More information about this study?

For more information about the research, you can contact the researcher Erik Welling directly at the following email address: ewelling@changefied.nl.

Alternatively, you can contact the supervisor, Remco Veltkamp, at the following email address: r.c.veltkamp@uu.nl.

9. Appendices:

In addition to this information sheet, you have also received a consent form.

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Consent form for participation in the research project Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation

Please complete the form below by ticking the relevant boxes and signing on the line below. A copy of the completed form will be given to you for your own record.

- ☐ I confirm that I am 18 years of age or over.
- ☐ I confirm that the research project **"**Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation**"** has been explained to me. I have had the opportunity to ask questions about the project and have had these answered satisfactorily. I had enough time to consider whether to participate.
- ☐ I consent to the material I contribute being used to generate insights for the research project "Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation**".**
- ☐ I understand that personal data will be collected from me as explained in the information sheet and that this data will be held confidentially so that only Erik Welling, Remco Veltkamp, Wolfgang Huerst and René de Bruin have access to this data and are able to trace it back to me personally. The data will be held on a password protected laptop for up to four months after which period it will be fully anonymized. In accordance with the General Data Protection Regulation (GDPR) I can have access to my personal data and can request it to be deleted at any time during this period.
- ☐ I understand that my participation in this research is voluntary and that I may withdraw from the study at any time without providing a reason, and that if I withdraw any personal data already collected from me will be erased.
- ☐ I understand that my participation is not a requirement for my course, and that participating or not will not impact me.
- ☐ I consent to allow the fully anonymized data to be used in future publications and other scholarly means of disseminating the findings from the research project.
- ☐ I understand that the data acquired will be securely stored by researchers, but that appropriately anonymized data may in future be made available to others for research purposes. I understand that the University may publish appropriately anonymized data in appropriate data repositories for verification purposes and to make it accessible to researchers and other research users.
- ☐ I agree to take part in the above research project on **"**Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation**"**.

Name of participant	Date	Signature
Name of researcher	Date	Signature

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Parent/guardian Research Participant Information Sheet

"Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation"

10-2023

1. Introduction

Your child has been asked to participate in a scientific study regarding the impact of collaboration in educational VR simulation games. The research will take place at the Techniekcollege Rotterdam.

2. What is the background and purpose of this study?

The Techniekcollege aims to incorporate the Virtual Reality (VR) game VR TechLab into the "Hardware for ICT Support" curriculum. In this game, you will learn about the various components of a computer, considerations when purchasing these components, and how to install them into a computer. The game also allows two students to play the same level simultaneously in the same virtual environment.

The purpose of this research is to determine the effect of this collaboration on learning outcomes, motivation, and overall satisfaction.

The game is produced by and is the property of Changefied.

3. Who will carry out the study?

The research will be conducted by Erik Welling as part of his master's thesis at the University of Utrecht, under the supervision of Remco Veltkamp and Wolfgang Huerst. Additionally, René de Bruin will be present during the research to provide support and guidance.

4. How will the study be carried out?

Throughout the remainder of the block, your child will play the VR game in support of their lessons. They will play the game divided into three to four sessions. Each session will last for half an hour. Half of the students will play the game exclusively on their own, while the other half will have the opportunity to play the levels together. No data will be collected during gameplay.

Erik Welling and/or René de Bruin will be available to assist with technical or content-related questions.

Just before the end of the block, your child will be asked to fill out a questionnaire about their experience with the game. This questionnaire will not be graded and will not impact their grade; it is solely for data collection purposes.

Following this, they will take their exam just as they would have taken if they had not played the game. The results from this exam will count toward their grade. It will also be used for the research.

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5. What will we do with your data?

The results of the questionnaire and the exam will be collected and stored on a password-protected laptop. The data will be kept confidential, with only Erik Welling, Remco Veltkamp, Wolfgang Huerst, and René de Bruin having access to this data. The data will be retained in a personally identifiable form for a maximum of six months and will then be fully anonymized. The anonymized data may be mentioned in research papers for transparency and potential follow-up studies. This research is conducted as Erik Welling's thesis project at the University of Utrecht during his internship at Changefied. Apart from Erik Welling, Changefied will not have access to personally identifiable data.

6. What are your rights?

Participation in the research is voluntary. We will only collect your data with your consent, which you can provide through the consent form. If you decide you do not want your child to participate in the research, you don't need to do anything. You are not required to sign anything or provide a reason for not participating. Your decision will not affect their grade or the course.

You have the right to withdraw your consent at any time, including during and after the research. We will not collect any further data from your child from that point, and all data collected up to that point will be deleted. However, we are not required to delete processed, anonymized data if you choose to withdraw from the study afterward.

7. Approval of this study

This research has been approved by the Research Institute of Information and Computing Sciences based on the Ethical Quick Scan. If you have any complaints about how this research is conducted, you can send an email to ics-ethics@uu.nl. If you have questions or complaints about the way the personal data of your child is used or processed, you can send an email to privacy-beta@uu.nl. They can assist you with questions and complaints about their personal data and your rights under the GDPR. For more details on our rights and obligations regarding personal data, see the University's privacy statement: www.uu.nl/en/organisation/privacy.

8. More information about this study?

For more information about the research, you can contact the researcher Erik Welling directly at the following email address: ewelling@changefied.nl.

Alternatively, you can contact the supervisor, Remco Veltkamp, at the following email address: r.c.veltkamp@uu.nl.

9. Appendices:

In addition to this information sheet, you have also received a consent form.

Universiteit Utrecht

Consent form parent/guardian for participation in the research project Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation

Please complete the form below by ticking the relevant boxes and signing on the line below. A copy of the completed form will be given to you for your own record.

- ☐ I confirm that I am 18 years of age or over.
- ☐ I confirm that I am the parent and/or guardian of the participant at the bottom of this form.
- ☐ I confirm that the research project **"**Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation**"** has been explained to me. I have had the opportunity to ask questions about the project and have had these answered satisfactorily. I had enough time to consider whether I want my child to participate.
- ☐ I consent to the material my child contributes being used to generate insights for the research project "Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation**".**
- ☐ I understand that personal data will be collected from my child as explained in the information sheet and that this data will be held confidentially so that only Erik Welling, Remco Veltkamp, Wolfgang Huerst and René de Bruin have access to this data and are able to trace it back to my child personally. The data will be held on a password protected laptop for up to four months after which period it will be fully anonymized. In accordance with the General Data Protection Regulation (GDPR) I can have access to the personal data of my child and can request it to be deleted at any time during this period.
- ☐ I understand that participation in this research is voluntary and that I may withdraw my child from the study at any time without providing a reason, and that if I withdraw any personal data already collected from my child will be erased.
- ☐ I understand that participation is not a requirement for the course, and that participating or not will not impact my child.
- ☐ I consent to allow the fully anonymized data to be used in future publications and other scholarly means of disseminating the findings from the research project.
- ☐ I understand that the data acquired will be securely stored by researchers, but that appropriately anonymized data may in future be made available to others for research purposes. I understand that the University may publish appropriately anonymized data in appropriate data repositories for verification purposes and to make it accessible to researchers and other research users.
- ☐ I agree that my child participates in the above research project on **"**Enhancing a Virtual Reality Educational Game with multiplayer capabilities: A case study of a computer assembling simulation**"**.

Name of parent/guardian	Date	Signature

Name of participant

Name of researcher	Date	Signature

From: GMT Ethics Review
To: Welling, E. (Erik)
Cc: Veltkamp, R.C. (Remco); ICS-Ethics
Subject: FW: Ethics and Privacy Quick Scan: Issues with thesis project
Date: Wednesday, April 19, 2023 4:39:31 PM

Dear Erik, cc Remco, cc ICS-Ethics,

I've reviewed your quick scan results. Here are my comments:

- Participants under 18: Is it strictly necessary that you conduct the study with participants under 18? Generally, such research should go through ethical approval from the ethics board. It may be possible to change the study design so that you do not need to recruit minors (e.g., care takers or parents as participants). If you think that it is necessary to include people under 18, you need informed consent from the parents.
- Conflict of Interest: This sounds ok if you do conduct the research as described and in alignment with your supervisor.

Please discuss these aspects with your supervisor and reach out if you have any questions.

Best Wishes,
Julian Frommel

Dr. Julian Frommel | Assistant Professor | Utrecht University | Information and Computing Sciences | Interaction, Multimedia | Minnaertgebouw 4.15 | Princetonplein 5, 3584 CC Utrecht, The Netherlands

URL to view Results	[Click Here]

Response Summary:

Section 1. Research projects involving human participants

P1. Does your project involve human participants? This includes for example use of observation, (online) surveys, interviews, tests, focus groups, and workshops where human participants provide information or data to inform the research. If you are only using existing data sets or publicly available data (e.g. from Twitter, Reddit) without directly recruiting participants, please answer no.

- Yes

Recruitment

P2. Does your project involve participants younger than 18 years of age?

- Yes

P3. Does your project involve participants with learning or communication difficulties of a severity that may impact their ability to provide informed consent?

- No

P4. Is your project likely to involve participants engaging in illegal activities?

- No

P5. Does your project involve patients?

- No

P6. Does your project involve participants belonging to a vulnerable group, other than those listed above?

- No

Ethics Warning.  **As you are dealing with vulnerable participants (yes to one (or more) of P2-P6) a fuller ethical review is required. Please add more detail on your participants here:**

The participants are Secondary Vocational Education Level 2 students. Some of these students might be younger than 18 years old.

P7. Do you intend to be alone with a research participant or have to take sole responsibility for the participants at any point during your research activity?

- No

P8. Does your project involve participants with whom you have, or are likely to have, a working or professional relationship: for instance, staff or students of the university, professional colleagues, or clients?

- No

Informed consent

PC1. Do you have set procedures that you will use for obtaining informed consent from all participants, including (where appropriate) parental consent for children or consent from legally authorized representatives? (See suggestions for information sheets and consent forms on the website.)

- Yes

PC2. Will you tell participants that their participation is voluntary?

- Yes

PC3. Will you obtain explicit consent for participation?

- Yes

PC4. Will you obtain explicit consent for any sensor readings, eye tracking, photos, audio, and/or video recordings?

- Not applicable

PC5. Will you tell participants that they may withdraw from the research at any time and for any reason?

- Yes

PC6. Will you give potential participants time to consider participation?

- Yes

PC7. Will you provide participants with an opportunity to ask questions about the research before consenting to take part (e.g. by providing your contact details)?

- Yes

PC8. Does your project involve concealment or deliberate misleading of participants?

- No

Section 2. Data protection, handling, and storage

The General Data Protection Regulation imposes several obligations for the use of **personal data** (defined as any information relating to an identified or identifiable living person) or including the use of personal data in research.

D1. Are you gathering or using personal data (defined as any information relating to an identified or identifiable living person)?

- No

Section 3. Research that may cause harm

Research may cause harm to participants, researchers, the university, or society. This includes when technology has dual-use, and you investigate an innocent use, but your results could be used by others in a harmful way. If you are unsure regarding possible harm to the university or society, please discuss your concerns with the Research Support Office.

H1. Does your project give rise to a realistic risk to the national security of any country?

- No

H2. Does your project give rise to a realistic risk of aiding human rights abuses in any country?

- No

H3. Does your project (and its data) give rise to a realistic risk of damaging the University's reputation? (E.g., bad press coverage, public protest.)

- No

H4. Does your project (and in particular its data) give rise to an increased risk of attack (cyber- or otherwise) against the University? (E.g., from pressure groups.)

- No

H5. Is the data likely to contain material that is indecent, offensive, defamatory, threatening, discriminatory, or extremist?

- No

H6. Does your project give rise to a realistic risk of harm to the researchers?

- No

H7. Is there a realistic risk of any participant experiencing physical or psychological harm or discomfort?

- No

H8. Is there a realistic risk of any participant experiencing a detriment to their interests as a result of participation?

- No

H9. Is there a realistic risk of other types of negative externalities?

- No

Section 4. Conflicts of interest

C1. Is there any potential conflict of interest (e.g. between research funder and researchers or participants and researchers) that may potentially affect the research outcome or the dissemination of research findings?

- Yes

C2. Is there a direct hierarchical relationship between researchers and participants?

- No

Ethics Warning.  **As you replied yes to C1 or C2, a fuller ethical review is required. Please provide more information regarding possible conflicts of interest and how you mitigate them here:**

I am a partial owner of the company that I am conducting my research for. This could potentially be considered a conflict of interest because I would prefer a positive outcome from my experiments. I will try to mitigate this as much as possible by keeping in close contact with my (impartial) supervisor. Furthermore will I use objective measurements wherever possible. Especially in areas in which I would prever a favourable outcome. Whenever I need to draw subjective conclusions I will be transparent on the data that I drew the conclusions from and try to draw those conclusions as honestly as possible keeping this potenital bias in mind. With all this combined I am confident that I will be able to mitigate this potential conflict of interest and conduct my research in an honest and unbiased manner.

Section 5. Your information.

This last section collects data about you and your project so that we can register that you completed the Ethics and Privacy Quick Scan, sent you (and your supervisor/course coordinator) a summary of what you filled out, and follow up where a fuller ethics review and/or privacy assessment is needed. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information. Please see the guidance on the ICS Ethics and Privacy website on what happens on submission.

Z0. Which is your main department?

- Information and Computing Science

Z1. Your full name:

Erik Welling

Z2. Your email address:

e.welling2@students.uu.nl

Z3. In what context will you conduct this research?

- As a student for my master thesis, supervised by::
  Remco Veltkamp

Z5. Master programme for which you are doing the thesis

- Game and Media Technology

Z6. Email of the course coordinator or supervisor (so that we can inform them that you filled this out and provide them with a summary):

r.c.veltkamp@uu.nl

Z7. Email of the moderator (as provided by the coordinator of your thesis project):

gmt-ethics@uu.nl

Z8. Title of the research project/study for which you filled out this Quick Scan:

This research does not have a title yet

Z9. Summary of what you intend to investigate and how you will investigate this (200 words max):

We will be investigating the problems, opportunities and difficulties that may arise when using VR to teach a practical skill instead of ordinary lessons. In particular, we will be looking at teaching students to assemble and disassemble pc's. I will start by assessing the current teaching method by interviewing the teacher and by giving a questionnaire to the students.
I will use this information to figure out what the positive aspects of the current teaching method are and how to maintain these aspects when translating to VR. Furthermore will I try to find what the shortcomings are of the current method and if I these could be negated in VR.
I will then create the aforementioned application and test its effectiveness compared to the previous teaching method.

Z10. In case you encountered warnings in the survey, does supervisor already have ethical approval for a research line that fully covers your project?

- No

Scoring

- Privacy: 0
- Ethics: 2
