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ASSESSING THE VALUE OF EARLY USER EXPERIENCE TESTING IN VR GAMES

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Despite the recent growth of market share of Virtual Reality (VR) gaming due to VR headsets price reduction, game companies are still facing a few obstacles related to VR games design and development. One of them is the lack of player-centred perspective in game design. User Experience (UX) assessment as one of the main tools of player-centred design offers a variety of methods that help investigate player behaviour, emotions, and experience. However, game companies are not in a hurry to proceed with UX on board due to disbelief and uncertainty about the benefits and costs of UX research. Academic literature offers little research investigating benefits and costs of UX research on actual game subjects. This thesis aims to diminish that knowledge gap.

The VR game 'Crumbling Factory' (CF) developed byTurku Game Lab and students of Turku University of Applied Sciences was commissioned as a subject of this research. Preliminary UX study was conducted where key issues were identified and a list of recommendations for further development was formulated. Two versions of CF were tested, namely Version One, an initial version of the game, and Version Two, a result of further development according to guidlines given by the preliminary UX study. Twenty people, ten people per each version, completed a survey and evaluated their experience with CF.

A comparative analysis of data gathered throughout the survey demonstrated that preliminary UX study was able to correctly identify problems in player experience with Version One of CF, and deliver accurate specific recommendations for its further development. That resulted into 66% growth of positive experience of Version Two compared to Version One.

The cost-benefit analysis of the preliminary study and further development process proved that the benefits of having UX evaluation as an integral part of game design and development process outweighed its costs. Although the goal of this study was not to determine whether or not Crumbling Factory is capable of succeeding on the market, the study demonstrated how closely player experience is tied to the game's revenue. In the light of the results of this thesis, it is recommended that game companies working with VR start integration of UX evaluation in the development process as early as on the first stages of game design.

KEYWORDS:

User experience, virtual reality, digital games, cost-benefit analysis

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LIST OF ABBREVIATIONS

CR	Crumbling Factory
VR	Virtual reality
UX	User experience

1 INTRODUCTION

The gaming industry, with 2.5 billion gamers all over the world who are estimated (Wijman, 2019) to spend 152 billion dollars on games by the end of 2019, is the largest and most profitable form of entertainment. Video games are an integral part of modern culture and people's lives. Games are referenced, games are played, games are streamed. Behind the phenomenon of such popularity stands the broad demographical accessibility of games (WePC.com, 2019) and a variety of genres and settings. In other words, anyone anywhere can find a game that satisfies their needs.

The gaming industry has also become a promoter and facilitator of the development and utilization of new technologies. Game development goes along with technological progress. As soon as new technology is developed, game developers rush to become familiar with it and try to estimate how it can be integrated into the current picture of the gaming industry. One of the latest examples of technology that was successfully utilized by the gaming industry is Virtual Reality (VR).

The first thoughts and implementations of VR-like equipment are dated back to the middle of 19th century when Charles Wheatstone described stereopsis, provided his explanation of binocular vision and later based on that, constructed the very first stereoscope. However, the first descriptions of the modern model of VR come from a short science fiction story "Pygmalion's Spectacles" written by Stanley Weinbaum in 1935. There (Weinbaum, 2016) he described a pair of goggles that enables "a movie that gives one sight and sound", where "you are in the story, you speak to the shadows, and the shadows reply, and instead of being on a screen, the story is all about you, and you are in it". Merriam-Webster dictionary defines 'virtual reality' as "an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment". Since 1987 the term 'virtual reality' has been heavily popularized by Jaron Lanier, founder of the Visual Programming Lab (VPL). VPL was the first company to sell Virtual Reality goggles (9400$ for pair) and gloves (9000$ for pair). Because of such high prices on VR equipment, for a long time, VR implementation existed only in the context of medical, scientific and military training and research.

The game industry acquisition of VR technology started in 1991 when Virtual Group launched Virtuality. Virtuality was a line of VR arcade machines that offered real-time

multi-player 3D gaming experience through a stereoscopic visor, joysticks and networking units. This was the first mass-produced VR-based gaming system. Since that time, many game and tech companies started investing money and resources into VR-based games and experiences. Not till a short time ago, the absence of VR-based games on the mass market due to the pricing on hardware and software equipment remained as one of the greatest obstacles of VR gaming. In recent years, that obstacle was overcome with commercial head-mounted displays, which reduced the costs to $300-800 for the headset. By 2019, hundreds of companies started developing VR related products. Among them were such tech giants as Google, HTS, Sony and Facebook. VR gaming started acquiring a market share. This market share is projected to reach a value of $40,2 billion by 2024, which is four times greatergreater than it was evaluated in 2018 (IMARC Group, 2019).

However, costly equipment is not the only problem in VR gaming. VR gaming differs from traditional gaming in many aspects (Roettl and Terlutter, 2018; Pallavicini et al., 2017). One of the most significant differences is that VR games require user-centred design approaches in its development. Such aspects as age, overall experience with video games, predisposition to motion sickness, emotional lability, and many more should be considered (Rosa et al., 2016) when developing VR experiences and games. F.Pallavicini, et.al. (2015) suggested that “Focusing on human factors from the earliest stages of designing VR training can increase effectiveness and reduce the possibility of ineffective or even harmful effect” of the VR experience. To address this problem, game designers started seeking advice from specialists in User Experience (UX) and Usability fields.

Usability in a game development context is a relatively new topic. Therefore, its definitions and terminology have not been well-identified yet. The official International Organization for standardization definition (ISO, 2018) of usability is: “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”. In a game development context, usability is defined (Pinelle et al., 2009) as “the degree to which a player is able to learn, control, and understand a game”. It addresses gameplay, game mechanics, and user interface, leaving aside considerations for entertainment, visuals, engagement and storyline (Rajanen and Nissinen, 2015). Therefore, usability alone is not sufficient to correctly understand and estimate player experience.

User Experience, on the other hand, is centred around player behaviour, thinking processes and capabilities. According to User Experience Professionals' Association (UPA, 2012), User Experience as a discipline is "concerned with all the elements that together make up that interface, including layout, visual design, text, brand, sound, and interaction". The role of the User Experience researchers and designers is to assist in better evaluation and prediction of the quality of user experience.

Usage of usability and UX tools in the game design process is proved to be beneficial (Sutcliffe, 2016; Nacke et al., 2010]. Studies claim that data gained through usability and UX research helps game development teams with successful iteration through the design process, justification of the changes and better reception of the final product by all stakeholders. However, all benefits come with the price. Among some of them are hiring costs, longer time to the market, disputes between stakeholders about research objectives. Correlations between benefits and drawbacks of having usability and UX tools as an integral part of the game development process have not been covered well in the existing literature. Furthermore, the number of papers available on usability discipline and general awareness about its costs and benefits (Rajanen and Nissinen, 2015) prevail over those covering the UX discipline, especially in the field of VR (Sutcliffe and Kaur, 2000; Bowman et al., 2002). VR is a field of the gaming industry that suffers the most from the luck of user-centred approach. In fact, it was named as (Jenkins, 2019) one of the main reasons why after more than 30 years on the market, the technology has not yet gained mass popularity. VR games and experiences evolve around first person viewpoint. Even the same name 'VR *experience*' proclaims that experience of the player is the pivot point of the technology. Yet, V. Heffernan in her "Magic and Loss: The Internet as Art" (Heffernan, 2016), describing her experience with VR and caused by it cognitive dissonance, expressed the somewhat popular opinion: "Virtual reality has always sounded fantastic in theory but felt in practice like brain poison". Persisting cognitive dissonance is one of the signs of poorly designed experience. It is not easy to fight human's perception of reality, however, there are tools that can help with that, and UX research is one of them. Of course, companies would like to know for sure if UX research is capable of improving the outcome of a product, and if improvements are realised, what is the cost. Therefore, this research focuses on the correlation between benefits and costs of using UX tools in the process of development of VR games and experiences. The goal of the research is defined as answering the question: "What is the value of early player experience assessment on a small-scale VR game project?"

2 CASE STUDY: CRUMBLING FACTORY

Turku Game Lab has offered Crumbling Factory, one of their VR projects, as a subject of this research. Crumbling Factory (CF) is a VR game developed by students of Turku University of Applied Sciences as part of their project course on Advanced Game Technologies. The project was later reassessed by Turku Game Lab and considered for further development. Crumbling Factory's setting is a nuclear power plant. The plant has regulation issues, and players are there to solve them. The goal of the game is to stabilize the factory by interacting with different types of controllers. Crumbling Factory is supposed to help people with no or little experience in VR become more familiar and comfortable with the technology. Therefore, it is crucial to make sure that the experience brings satisfaction and fulfills its purpose.

2.1 Preliminary study

In summer 2019 a piece of User Experience and Usability Research was conducted by a research group as a part of TUAS' Game Testing course. Twenty-six people of different ages, background and experience with gaming and VR, took part in the survey. The research revealed major usability and user experience issues. A full table of issues delivered in the research is available in the appendix (see Appendix 1). In general, participants claimed that although it was possible to become familiar with VR technology using Crumbling Factory, beginners felt lost and frustrated throughout the game, and more advanced players felt extremely bored. The research concluded that for Crumbling Factory to succeed, developers must address and resolve unpleasant player experiences.

2.2 Current study

For the purpose of this study, two versions of Crumbling Factory were tested for Player Experience. The first version (so-called Version One) of the Crumbling Factory was developed by students (so-called Development Team) as part of a project course. The second version (so-called Version Two) was revised and modified by another group of students, who also were part of a project course, according to suggestions provided by

preliminary research. The first 10 participants of this UX research were asked to evaluate the Version One of CF, the other ten participants were asked to evaluate the Version Two of CF. The same questionnaire was used for both groups. The comparative analysis of the data gathered from both groups together with the detailed information about costs from the Development Team will be evaluated by this research. Figure 1 shows the general flow of this research.

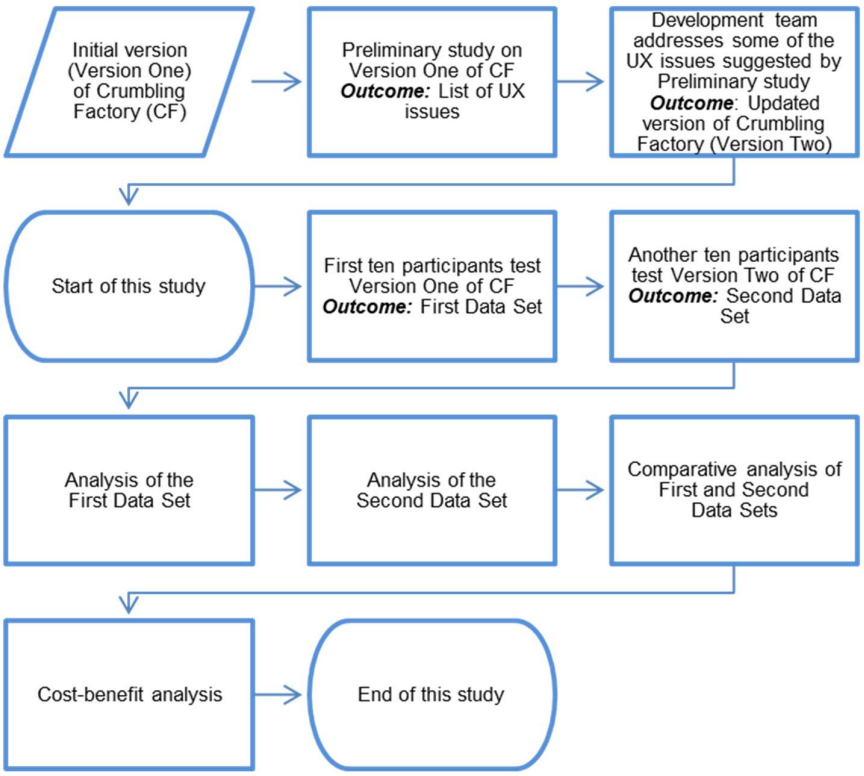

Figure 1. Stages of development of this research.

There were several reasons why Crumbling Factory was considered the best fit for the scope of this research. Firstly, the project was still in the early stages of development, hence it was easier to affect the development process with changes. Late discovery of UX issues, increases the cost of their elimination. The goal of this research is to investigate a connection between costs and benefits of UX research in early stages of the design process. Secondly, a new version of Crumbling Factory, which was developed according to recommendations from preliminary study, was already available. It created a possibility to conduct comparative cost-benefit analysis. Additionaly, a short time required to play through the game, and a target audience that is easy to recruit made it easier to conduct time-effective quantitative UX research.

3 METHODS

3.1 Defining user experience research method

The user experience discipline offers many tools and techniques for researchers to analyse the experience. UX research methods are usually categorized as attitudinal or behavioural and qualitative or quantitative. For the purpose of this research, an attitudinal quantitative method in the form of a survey questionnaire at its core was chosen. Surveys aim to measure and categorize attitudes by collecting self-reported data (Rohrer, 2014). They are useful when research requires access to a diverse group of users in a short time frame. Data gathered through the survey's questionnaire is coded numerically and hence suits better for the mathematical analysis.

Context is another aspect that greatly affects the research method. UX research in a gaming industry context has specific characteristics (Nielsen, 2016; Mirza-Babaei, 2018) that need to be considered when developing the survey. For example, while usually in other industries projects have very concise objective purposes (e.g. help a user to buy products from a web shop), the ultimate purpose of games is having fun. Fun is subjective, and there are many conventional and nonconventional ways of achieving it. In the case of a web shop, the easier the process goes, the better is user experience, in games challenges are proven to enhance engagement and fight boredom, leading to a better player experience.

Although user experience in the gaming industry has been in overview for quite some time, there are not that many available frameworks for measuring player experience (Norman, 2013). IJsselsteijn et al. (2007) admitted that there are obstacles that make it difficult to construct a multi-purpose framework. W. IJsselsteijn and his colleagues have produced one of the most commonly used nowadays frameworks (IJsselsteijn et al., 2013). Their Game Experience Questionnaire (GEQ) was used as a base for this research's survey.

3.2 Questionnaire design

VR games differ from traditional video games and boardgames in many aspects: perception of reality (Pallavicini et al., 2017), player satisfaction (Shelstad et al., 2017),

level of immersion (Pallavicini et al., 2017), cybersickness (Suarez, 2019), etc. These aspects should be taken into account not only in the development of VR games, but also when evaluating player experience. Context variables, the ones that depend on the case subject, also shall not be overlooked. Crumbling Factory has special characteristics such as the absence of a social component and competition, which were examined when modifying GEQ. Some parts (ex. Social Presence Module) and questions were considered redundant in the context of CF and, therefore, removed. Additionally, questions about overall experience with games and VR as well as the assessment of separate significant (Alexiou and Schippers, 2018) game elements (e.g. theme, audio, graphics) were included for a better understanding of what causes particular attitude. Appendix 2 presents a full detailed overview of the questionnaire. Figure 2 shows the questionnaire's flow and its main parts.

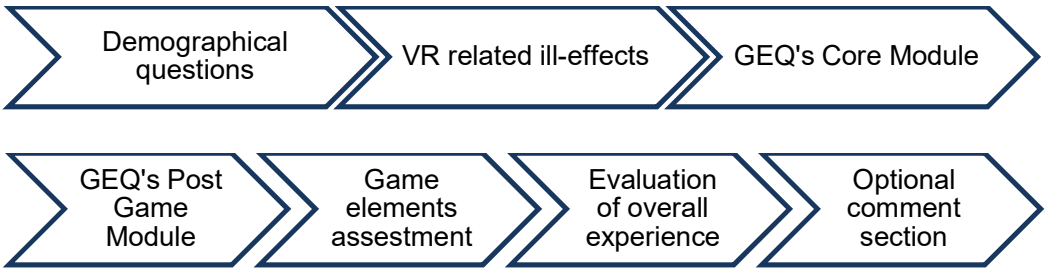

Figure 2. Flow of the UX survey's questionnaire that displays its main parts.

Questionnaire consisted of 7 parts:

1. Demographical questions.

   There are 5 demographical questions that provide the researcher with the insight of what kind of background participants have, and how are results of the questionnaire differ on the demographical scale. Demographical module included diversity criteria questions that help to determine participants' level of experience with VR technology (rated on a scale from 1 to 5 where: '1' stands for "Extremely poor, never interfered" and '5' stands for "Extremely advanced, i.e. developed VR games and/or more than often user of VR") as well as level of experience with games and involvement into game community (rated on a scale from 1 to 5 where: '1' stands for "I do not consider myself an active member of the game community and/or a gamer" and '5' stands for "It is true to the extreme extent that I am an active member of the game community and/or a gamer".

2. VR related ill-effects.
   Participants are encouraged to inform cybersickness if they experience any.
3. GEQ's Core Module.
   Questions related to how participants felt while playing the CF.
4. GEQ's Post game module.
   Questions related to how participants felt after they finished playing the CF.
5. Game elements assessment.
   Participants are asked to evaluate their experience with particular game elements.
6. Evaluation of the overall experience with CF.
   Two questions helped to determine if, from participants' point of view, Crumbling Factory full-filled its goal to familiarize beginners with VR technology, and what kind of experience that was.
7. Comment section.
   Participants had an opportunity to provide extra comment and express their opinions on their player experience or report issues with the survey conduction.

3.3 Target population criteria and recruiting method

Target population criteria:

- Participants must not have used Crumbling Factory before;
- Participants must not have taken part in the development of Crumbling Factory;

Crumbling Factory targets people with no or little experience in VR. Therefore, it was important to ensure that most of the participants comply with the 'VR beginner' standard. Second year students of Turku University of Applied Sciences were asked to participate in the survey because as field specialization starts in TUAS only from the third year, the chance that second year students have never interacted with advanced modern gaming technology such as VR was very high.

No tangible or intangible reward was provided as an extrinsic motivator.

3.4 Survey workflow

The survey was conducted on the 22nd of October 2019 at the Turku Game Lab facility. VR station with Oculus headset and controllers was set up beforehand. The questionnaire form was available in electronic format via Google Forms. The participants were invited one by one. The participants were informed that the survey was voluntary and anonymous, and that they were free to leave any time during the survey if they felt uncomfortable. Moreover, the participants were informed that the survey moderator did not take any part in the development process of Crumbling Factory and had no profit from it. That was done to reduce participant biases, for example social desirability and acquiescence biases. There was no time limit for participants, and they could play CF as many times as they needed to form an opinion. After that, the participants were asked to anonymously complete the questionnaire provided in the form of the link to Google Forms. There were no time restrictions on completing the questionnaire.

3.5 Analysis tools and methods

GEQ Scoring guidelines (IJsselsteijn et al., 2013) were used to assess Core and Post Game modules of the questionnaire. For the rest of the questionnaire, tools as Google Forms Response Analysis and Microsoft Excel was used to conduct statistical analysis and visualize the data.

4 FINDINGS

4.1 Version One of Crumbling Factory

Ten participants tested Version One of Crumbling Factory.

4.1.1 Demographical background of the participants

The average age of participants was around 22 years old. Most of the participants were unemployed students, who were proceeding with their first college degree. 70% of the participants had no or little experience with VR technology. 80% of all participants considered themselves active members of the game community and/or gamers.

4.1.2 VR related ill-effects

Overall, 10 cases of VR related ill-effects were reported. Among those, 4 counts of ‘blurred vision’, 2 counts of ‘difficulty focusing’, 1 count of ‘eyestrain’, 1 count of ‘general discomfort’ and 1 count of ‘nausea’. Neither of the effects felt bad enough for the participants to quit the survey. All the effects were reported after the try-out of Crumbling Factory.

4.1.3 Core module

The core module was represented by 33 questions that evaluated player’s feedback on their overall experience of the Crumbling Factory on the scale from ‘not at all’ (0 points) to ‘extremely’ (4 points). The scoring was done according to GEQ Core Module Scoring Guidelines (IJsselsteijn et al., 2013). Core Module assessed 7 components, which are provided in Table 1. Components scores were computed as the average value of items (questions) on the scale from 0 to 4 where 4 is the greatest. A more detailed score-per-item table is available in the appendix (see Appendix 3).

Table 1. Score-per-component table that contains results from the Core module of questionnaire for Version One.

Component	Short explanation	Score
Competence	How easy it is for the player to achieve the game's goals.	1,6
Sensory and Imaginative Immersion	Level of player's engagement.	1,8
Flow	Level of player's attentiveness and absorption.	1,8
Tension/Annoyance	How frustrated and unsatisfied player feels.	0,5
Challenge	How much effort player gives to the game.	1,6
Negative affect	How bored and tired player feels during the game.	0,6
Positive affect	How much player enjoys the game and how happy they are.	2,1

4.1.4 Post-game module

The post-game module was represented by 17 questions that evaluated player's feedback on the scale from 'not at all' (0 points) to 'extremely' (4 points). The scoring was done according to the GEQ Post-Game Module Scoring Guidelines (IJsselsteijn et al., 2013). Post-Game Module assessed 4 components, which are provided in Table 2. Components scores were computed as the average value of items (questions) on the scale from 0 to 4 where 4 is the greatest. A more detailed score-per-item table is available in the appendix (see Appendix 3).

Table 2. Score-per-component table that contains results from the Post-game module of questionnaire for Version One.

Component	Short explanation	Score
Tiredness	How exhausted, tired and disoriented player felt after playing the game.	0,1
Returning to reality	If after playing the game player had a feeling that they returned from a jorney.	0,2
Positive experience	How powerful, proud and energized player felt after playing the game.	0,9
Negative experience	If player felt guilty, ashamed and regretful after playing the game.	0,1

4.1.5 Game elements assessment

Participants assessed 11 basic game elements that are considered standards in game design (Yee, 2006). It was assumed that participants are familiar with what stands for each game element as all the participants were students of the ICT department at TUAS, and most of them identified themselves as active members of the game community. The results are presented in Table 3.

Table 3. Score-per-component table that contains results from the Game elements assestment module of questionnaire for Version One.

Component	Score
Motivation	1,8
Engagement	2,1
Challenge	2,4
Emotional attachment	0,9
Learning outcome	1,8
Story/Narrative	1,2
Theme and Setting	1,7
Interactions and Control	2,7
User interface	2,4
Graphical elements	2,5
Sound	2,0

It is worth noticing that even though Version One of Crumbling Factory did not include any sound, the item ‘Sound’ was evaluated as high as 2.0 points out of 4,0 on average. Furthermore, Version One did not include any UI elements. Meanwhile item ‘User Interface’ scored 2,4 out of 4,0 on average.

4.1.6 Comments left by participants

In order to preserve the privacy of the participants, the following codes are used instead of names and other personally identifiable information: P01 for Participant 1, P02 for Participant 2, etc.

Overall, participants mostly expressed positive feelings about their try-out of Crumbling Factory. Some of them noticed (P01, P03, P10) that the game was too short to get a profound opinion: “I don’t think the game was long enough to really get a good opinion

on the experience". Several people (P03, P05, P08) expressed confusion with what was the point of the game: "The experience was quite confusing. The controls were intuitive after a few tries and so on, but first I managed to get myself lost in darkness and then couldn't figure out really anything I was supposed to do". P09 wrote: "I felt absolutely lost in the environment. There were no instructions or hints. With the headset limiting my vision, I felt totally vulnerable and at times miserable".

4.2 Version Two of Crumbling Factory

Eleven participants tested the Version Two of Crumbling Factory. One participant left the survey before trying out Crumbling Factory out of fear of experiencing an anxiety attack.

4.2.1 Demographical background of the participants

The average age of participants was around 25 years old. Most of the participants were unemployed students, who were proceeding with their first college degree. 60% of the participants had no or little experience with VR technology. 60% of all participants considered themselves active members of the game community and/or gamers.

4.2.2 VR related ill-effects

Overall, 8 cases of VR related ill-effects were reported. Among those, 2 counts of 'blurred vision', 2 counts of 'tired eyes', 2 counts of 'dizziness', 1 count of 'headache' and 1 count of 'difficulty concentrating'. Neither of the effects felt bad enough for the participants to quit the survey. All the effects were reported after the try-out of Crumbling Factory.

4.2.3 Core module

The core module was represented by 33 questions that evaluated player's feedback on their overall experience of the Crumbling Factory on the scale from 'not at all' (0 points) to 'extremely' (4 points). The scoring was done according to the GEQ Core Module Scoring Guidelines (IJsselsteijn et al., 2013). Core Module assessed 7 components, which are provided in Table 4. Components scores were computed as the average value

of items (questions) on the scale from 0 to 4 where 4 is the greatest. A more detailed score-per-item table is available in the appendix (see Appendix 3).

Table 4. Score-per-component table that contains results from the Core module of questionnaire for Version Two.

Component	Short explanation	Score
Competence	How easy it is for the player to achieve the game's goals.	1,3
Sensory and Imaginative Immersion	Level of player's engagement.	1,8
Flow	Level of player's attentiveness and absorption.	2,7
Tension/Annoyance	How frustrated and unsatisfied player feels.	0,9
Challenge	How much effort player gives to the game.	2,4
Negative affect	How bored and tired player feels during the game.	0,5
Positive affect	How much player enjoys the game and how happy they are.	2,4

4.2.4 Post-game module

Post-game module was represented by 17 questions that evaluated player's feedback on the scale from 'not at all' (0 points) to 'extremely' (4 points). The scoring was done according to GEQ Post-Game Module Scoring Guidelines (IJsselsteijn et al., 2013). Post-Game Module assessed 4 components, which are provided in Table 5. Components scores were computed as the average value of items (questions) on the scale from 0 to 4 where 4 is the greatest. More detailed score-per-item table is available in the appendix (see Appendix 3).

Table 5. Score-per-component table that contains results from the Post-game module of questionnaire for Version Two.

Component	Short explanation	Score
Tiredness	How exhausted, tired and disoriented player felt after playing the game.	0,1
Returning to reality	If after playing the game player had a feeling that they returned from a jorney.	1,1
Positive experience	How powerful, proud and energized player felt after playing the game.	1,5
Negative experience	If player felt guilty, ashamed and regretful after playing the game.	0,1

4.2.5 Game elements assessment

Participants assessed 11 basic game elements that are considered standards in game design (Yee, 2006). It was assumed that participants are familiar with what stand for each game element as all the participants were students of ICT department at TUAs, and most of them identified themselves as active members of game community. The results are presented in Table 6.

Table 6. Score-per-component table that contains results from the Game elements assessment module of questionnaire for Version Two.

Component	Score
Motivation	2,7
Engagement	2,4
Challenge	2,7
Emotional attachment	1,3
Learning outcome	1,9
Story/Narrative	1,2
Theme and Setting	2,0
Interactions and Control	2,4
User interface	2,0
Graphical elements	2,2
Sound	2,3

4.2.6 Comments left by participants

In order to preserve privacy of the participants, the following codes are used instead of names and other personally identifiable information: P01 for Participant 1, P02 for Participant 2, etc.

Overall, participants mostly expressed positive feelings about their try-out of Crumbling Factory. Several of them (P03, P04, P10) noticed that the game lacked profound tutorial. P02 was one of the participants who commented on that: “I would like to have better info about the different tasks or actions that I can do in game”. The other participant (P09) expressed their concern with motion sickness that they experienced during the try-out: “It was my first VR experience and I felt it bit hard, feeling of motion sickness was my biggest problem”. P05 also pointed out the fact that they experienced a cognitive

dissonance: “I was also bit worried that I’m might hit some physical obstacles like walls even I know I wasn’t physically moving”.

5 COMPARATIVE ANALYSIS OF VERSION ONE AND VERSION TWO OF CRUMBLING FACTORY

The development team that was working with Crumbling Factory at the time, made several modifications and implemented some new features, which resulted in Version Two of Crumbling Factory. The modifications and new features are listed here:

- Added a short game description in the beginning of the game;
- Made graphical presentation of the current state of the game visible in 3 ways: current heat level, state of the door and door lockdown timer;
- Added end game statistics screen containing information about overall gameplay session;
- Increased range of teleportation mechanics;
- Added new 3D models for the terminals;
- Improved materials for the terminals and other interactable objects;
- Added sound effects upon basic interactions (buttons, levers, valves);
- Added sounds for malfunction announcement and main door opening/closing.

5.1 Demographical background of the participants

There was no significant difference identified between the demographic backgrounds of the first set of participants, who tested Version One of Crumbling Factory, and the second set of participants, who tested Version Two of Crumbling Factory.

5.2 VR related ill-effects

10 cases of VR related ill-effects were reported by 6 participants who tested the Version One. 8 cases of VR related ill-effects were reported by 6 participants who tested Version Two. Although there is a decrease in the number of cases reported for the Version Two, there is no way to determine if that decrease was caused by improvement or degradation in the player's experience, and not by circumstances and player's ability to handle motion sickness.

5.3 Core module

Table 7 is a comparative table of components in the Core module. Table 1 presents scores per each component in the module as well as a difference in scores per version. A detailed score-per-item comparative table is available in the Appendix (see Appendix 3).

Table 7. Comparative table that contains the evaluation of components of the questionnaire's Core module.

Component	Version One (v1)	Version Two (v2)	Difference (v2 – v1)	Difference (v2 – v1) in %
Core Module				
Competence	1,6	1,3	-0,3	-19%
Sensory and Imaginative Immersion	1,8	1,8	0,0	0%
Flow	1,8	2,7	0,9	50%
Tension/Annoyance	0,5	0,9	0,4	80%
Challenge	1,6	2,4	0,8	50%
Negative affect	0,6	0,5	-0,1	-17%
Positive affect	2,1	2,4	0,3	14%

According to Table 7, a few trends can be identified. Firstly, the table demonstrates that component 'Challenge' experienced a dramatic rise of 50%, which indicated that the participants who tested Version Two felt time pressure and were required to put more effort into the game. An increase in the difficulty level of the game could have become one of the factors why the general competence of the players dropped by 19%. Participants who tested Version Two were more likely to feel less skillful and slower at reaching the game's targets. That could have also become one of the factors of considerable increase of 80% in tension and annoyance that participants have experienced with Version Two.

Although the described above trends tell that the difficulty of the game was increased, we know that the actual difficulty of the game was not changed between two versions, meaning that no game time, level structure, player's conditions were changed. It means that the only thing that changed was a player's perception of the difficulty of the game. The reason that could be put behind it is a change in the display of statistics and goals of the game that was implemented by the development team. Opposite to the Version

One, the Version Two draws a clear picture of the game's settings and goals and delivers a better display of states of the game and end game statistics. As the game started throwing constant reminders about its challenge, players started feeling more pressured (see Figure 3).

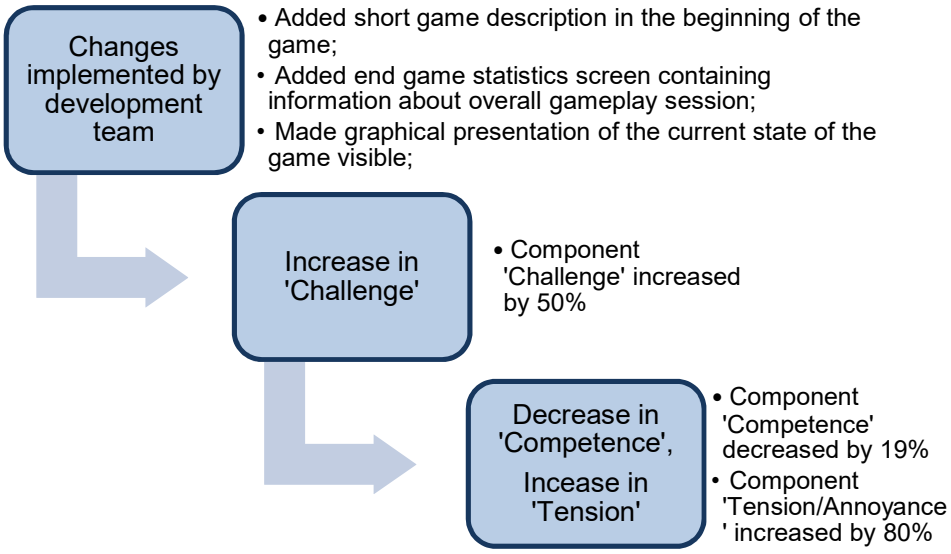

Figure 3. Visual representation of findings of the Core module.

Regardless of how it looks, the tendency illustrated above should not necessarily be qualified as negative. Games are designed to offer challenges. Challenge is what makes games fun and enjoyable (Cox et al., 2012). Of course, it is important to ensure that the difficulty level of the challenge stays in the golden middle relative to the targeted group of players: it should not be too easy to bore players, and it should not be too difficult to cause negative feelings in players. But in the case of Crumbling Factory, the increase of challenge can be viewed only as a positive change. Proof of that would be a decrease in 'Negative affect' by 17% and an increase of 'Positive affect' by 14%. It means that participants who tested Version Two felt happier and more satisfied when playing the game.

Another trend presented by the analysis of the findings is a remarkable growth of the 'Flow' component by 50% and a stagnation of 'Sensory and Imaginative Immersion'. Flow and immersion are one of the most important elements that are responsible for leveraging player's experience (Michailidis et al., 2018). In this study, immersion

represents how imaginative players felt while playing a game, how interested they were in the story, how aesthetically pleasant the experience was. Meanwhile, flow in this research determines a level of player's attentiveness and absorption. Data showed that the level of flow in Version Two increased to nearly twice the number that it came to be for Version One. It means that participants who played Version Two felt more engaged with the game. Most of the time flow and immersion go along with each other to the point where their differences remain disputable in academic circles. Although in the general overview, the level of immersion maintained the same level between both versions, a closer look at some questions gives a better understanding. One the one hand, item 'I was interested in the game's story' has shown an increase of 50%, which could be connected to the addition of a short game description in the beginning of the game. On the other hand, item 'I found it impressive' shown a decrease of 24%. Both items represent a highly subjective opinion as feedback of the player depends on multiple factors: from age to previous experience with video games. Nevertheless, it is important to track those items, because the result is useful and relevant when a pool of participants is representative of the target group.

5.4 Post-game Module

Table 8 is a comparative table of components in the Post-game module. Table 2 presents scores per each component in the module as well as the difference in scores per version. A detailed score-per-item comparative table is available in the Appendix (see Appendix 3).

Table 8. Comparative table that contains the evaluation of components of the questionnaire's Post-game module.

Component	Version One (v1)	Version Two (v2)	Difference (v2 – v1)	Difference (v2 – v1) in %
Post-game Module				
Positive experience	0,9	1,5	0,6	67%
Negative experience	0,1	0,2	0,1	100%
Tiredness	0,1	0,2	0,1	100%
Returning to reality	0,2	1,1	0,9	450%

The aftermath of the player's experience is presented in the Table 8. Post-game Module included 4 components, each of which assesed player feelings after the end of the game. It is important to point out how both 'Positive experience' and 'Negative experience' saw a growth of 67% and 100% respectively in Version Two. Growth of the negative experience could be a sum of several factors including escalated tiredness (by 100%) of the players in response to their perception of increased difficulty of the game. 'Returning to reality' was another component that received a major increase of 450%. Flow and immersiveness of the experience are responsible for how difficult it would be for the player to return to reality. 'Flow' component of the Core module increased by 50%, as a direct result, 'Returning to reality' component of the Post-game module increased as well.

5.5 Game elements assessment

Table 9 is a comparative table of components in the Game elements assestment module which presents scores per each component in the module as well as the difference in scores per version.

Table 9. Comparative table that contains the evaluation of components of the questionnaire's Game elements assessment module.

Component	Version One (v1)	Version Two (v2)	Difference (v2 – v1)	Difference (v2 – v1) in %
Game elements assessment				
Motivation	1.8	2.7	0,9	50%
Engagement	2.1	2.4	0,3	14%
Challenge	2.4	2.7	0,3	13%
Emotional attachment	0.9	1.3	0,4	45%
Learning outcome	1.8	1.9	0,1	6%
Story/Narrative	1.2	1.2	0,0	0%
Theme and Setting	1.7	2.0	0,3	18%
Interactions and Control	2.7	2.4	-0,3	-11%
User interface	2.4	2.0	-0,4	-17%
Graphical elements	2.5	2.2	-0,3	-12%
Sound	2.0	2.3	0,3	15%

In the last module participants were asked to evaluate 11 game components which represent significant aspects of game design. According to gathered data, participants who played Version Two of Crumbling Factory gave higher evaluation to most of the components than participants who played Version Two did. Such components as ‘Motivation’, ‘Emotional attachment’ and ‘Engagement’ shown a growth of 50%, 45% and 14% respectively, which indicated that players felt more emotionally comfortable and interested in Version Two of CF. Although ‘Story/Narrative’ component remained steady, ‘I was interested in the game's story’ item from Core module increased by 50%. This kind of behaviour cannot be analysed in this research as chosen research method did not imply follow-ups. Another interesting trend presents a more negative evaluation of ‘Interactions and Control’, ‘User Interface’ and ‘Graphical elements’ components of Version Two. Those components were in the area of improvement done by Development Team, but the participants were not able to identify it. For example, when Version One contained only untextured 3D models, Version Two was improved on that aspect with textures provided for each incomplete model. A/B testing should be implemented for two versions to investigate this issue.

5.6 Summary

Both versions of Crumbling Factory received negative and positive feedback from the participants of the survey. In the end, the average positive growth of the experience (growth of components that indicated a positive change in player’s experience) is 66%, and the average negative growth of experience (growth of components that indicated a negative change in player’s experience) is 45%. It indicates that the implementations by the development team played a significant role in refining player experience. Positive experience is the ultimate goal of every game, but in the scope of User experience research, negative feedback is also very important as it helps to identify problems and target them on the next iteration of designing and development process. For example, the post-game module revealed some inconsistencies in player’s experience (rise of negative experience and tiredness), and that is valuable knowledge that should be considered in the further development process.

6 COST-BENEFIT ANALYSIS

6.1 Costs of UX research

Estimating costs of UX research is a challenging task, mostly because UX research cost estimation contains too many variables, starting from what kind of research a company wants (Moran, 2019), and ending with how big the scope of a project is and on what stage of game development process research is conducted. For example, qualitative research is considered one of the most expensive because of its laborious and time-consuming nature. Some techniques, for instance, eye tracking testing require special equipment and software for gathering and analysing data, which always makes such research even more complex and expensive. The complexity of estimation of UX research costs results in an absence of fixed rates and prices on the market. Hiring a freelance UX researcher might cost around 30-70$ per hour and hiring an agency to conduct such research might cost even more. At the end of the day, a rule of thumb is that the cost of UX research depends on how much a company is ready to invest to get the most accurate result.

In this research case, the development team followed guidelines provided in findings delivered by the preliminary research. No rewards were offered for participants of the preliminary study. Therefore, only time spent on preparation, conduct and analysis of UX research can be evaluated. Table 10 shows a detailed overview of the time costs of preliminary UX reseach. A total of 120 hours was spent by an unexperienced UX researcher to conduct a full investigation on a small-sized VR game project on its early stages of development.

Table 10. Detailed overview of time spent on preliminary UX reseach.

Task	Time, in hours
Project introduction	8
Goal definition	8
Analysis of UX methods and development of survey materials	32
Participants recruitment	8
Players testing	24

continue

Table 10 continued

Analysis of data	30
Defining design guidlines for further development	10

6.2 Development costs of Version Two of Crumbling Factory

Development Team implemented several improvements and features following guidelines provided by Preliminary Study that resulted in Version Two of Crumbling Factory. The development team consisted of 6 final-year students of Game development degree of Turku University of Applied Sciences. According to the Development Team, they put 13-19 hours per team member, around 100 hours in total, into creating Version Two of Crumbling Factory.

6.3 Benefits of UX research

The purpose of this research is not to predict whether or not Crumbling Factory will succeed on the market. Such predictions require complex economic models and most importantly tend to underestimate results. The main reason behind underestimation is that there are too many factors that determine whenever VR game product receives recognition on the market. Among those are efficiency of marketing, including advertising, selling, and delivering of the product, and situation of the VR hardware market, including the current cost of an average-quality VR set. Although effective marketing is responsible for getting players to buy and download the game, it cannot ensure that players will proceed with the game. Player experience, on the other hand, takes that engagement responsibility and makes sure that players engage with the game, become part of the game community, contribute their money, and in a best-case scenario, form a fanbase. Therefore, player experience is closely tied to game revenue (Huang et al., 2019).

Although, this study cannot predict the success of Crumbling Factory, it proves that UX research contributed to positive change in player experience. This study has shown that the development team succeeded at leveraging player experience by following recommendations provided from preliminary UX research. Preliminary UX research was

able to identify upsides and downsides of player experience with Crumbling Factory and allocate elements that required improvement.

6.4 Summary

In this research one iteration of game design, development and UX evaluation process consists of following (see Figure 4): survey preparation, conduct of the survey, data analysis, formulation of recommendations to the development team based on survey's findings, re-design of the game according to the UX evaluation suggestions, implementation of new features based on re-design, release of new version.

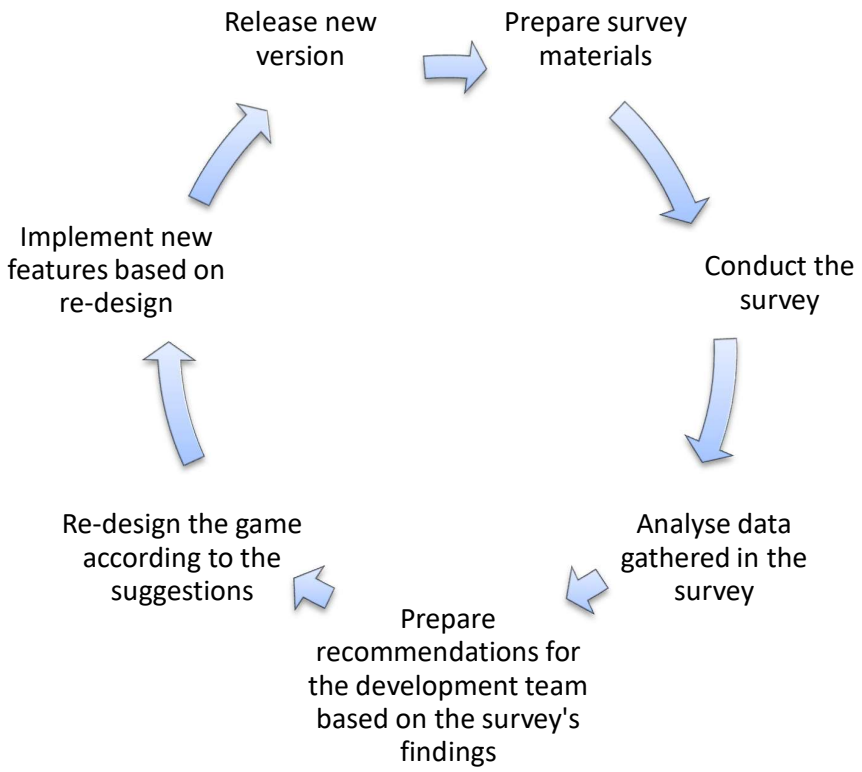

Figure 4. Visual representation of one development iteration that includes UX evaluation.

A total of 220 working hours, which is about 3 working weeks, considering that development team was working on their tasks simultaneously, was spent on one iteration by final-year students of Game Development degree of Turku University of Applied Science to conduct a full UX research (preliminary study) and implement some of the

features according to the table of improvements suggested by preliminary study (see Appendix 1). Even though only 6 out of 15 issues have been addressed, the positive growth of player experience resulted in 66%. It is a remarkable improvement achieved by semi-professionals. In the case of industry professionals following the same steps, UX assessment would be even more cost and time effective.

7 LIMITATIONS

There are two major limitations in this study that could be addressed in future research. Firstly, a questionnaire survey was chosen as the main method of the study as this quantitative type of analysis is more suited for comparative analysis and time shortage. However, there are some downsides to surveys and questionnaires, such as inability of a researcher to interact with the participants directly and clarify interpretation of the questions in case of imperfect wording. Furthermore, surveys have a higher participation rate if they are anonymous. But the anonymity of participants restricts a researcher's ability for a follow-up. In future research, different UX methods should also be considered. Secondly, because of the limited ability of a researcher to gain access to the target group, a sample pool of the participants might be a subject of limitation. Second year students of Turku University of Applied Sciences were offered to participate in the survey. Although survey results showed some diversity among participants, including age and background, most of the participants showed to be active members of game community. Random sample by 'I consider myself an active member of the game community and/or a gamer' criteria should be a matter of concern in future research.

8 CONCLUSION

VR gaming is a very special niche of the gaming industry as it has many specifics compared to typical video and mobile gaming. Perception of reality, player satisfaction, level of immersion, cybersickness – all of these specifics and many more must be considered in the development of VR games. Design and development of ordinary games is already an expensive and challenging process. No matter how large a company is and how many resources it has, there is always a high chance of a game's failure on the market. The increased complexity of the development of VR games and factors that affect a game's success on the market have made companies wonder what could be done to anticipate the success of their investments, ensure that their expenses are justified and lead to a better position of VR games on the market.

A user-centred approach is a relatively new approach in the gaming industry, and it is a technique that all VR games designs are striving for nowadays. The user-centred approach, focuses on players, their goals and needs, thus putting them in the centre of the game design and development process. User experience is one of the main tools of user-centred design that helps evaluate player expectations, emotions and behaviour. UX research can determine what kind of experience a player has and what affects it. By delivering accurate motivational results, UX research contributes to identifying the problems in an actionable and applicable format. Those results make it easier for developers to take action on the underlined improvement suggestions and deliver a better player experience in the next development cycle. Although there are many advantages in conducting UX evaluations, companies want to see a clear picture on what the connection between benefits and costs of player experience assessment in VR games is. Unfortunately, there is only a small number of studies available that evaluate the player-centred design approach with UX research as its main tool as well as its benefits and costs. Therefore, the research carried out in this thesis addressed that knowledge gap.

This research aimed to identify benefits and costs of running UX evaluation and, based on the findings delivered by a preliminary UX evaluation, further development of a small-sized VR gaming project called Crumbling Factory in its early stages of development was undertaken. This study assessed two version of Crumbling Factory, where Version One was an initial version of the game, and Version Two was a result of improvements

implemented by the development team according to the findings delivered by the preliminary UX study. Twenty participants took part in the survey, ten per each version of Crumbling Factory. Based on quantitative comparative analysis of player's experience with both versions, the research concluded that the average positive growth of the experience (growth of components that indicated positive change in player's experience) was 66%, and the average negative growth of experience (growth of components that indicated negative change in player's experience) was 45%. The results indicated that improvements implemented by the development team who followed guidelines provided by a preliminary study, played a significant role in boosting player experience. This study has shown that preliminary UX research was able to pinpoint correct areas for further development improvement in a specific, accurate, and motivational manner that made it possible for developers to address the findings.

The next stage of this research was to identify costs related to conduct preliminary UX research as well as further development featuring recommendations from the preliminary UX research. It is worth noticing that identifying success and revenue of Crumbling Factory on the market was not a prerogative of this research. Having mentioned that, based on the literature overview, the research concluded that positive player experience is one of the factors that leads to success on the market. Player experience is also closely tied to game revenue: the more players engaged with a game, and engagement aspect is one of the sides of player experience, the more willingly they will support the game with their money. According to this research's findings, around 3 full-time working weeks of 7 people were spent on one iteration. Considering that the iteration was completed fully by semi-professionals, the research concluded that if the iteration was conducted by industry professionals, it would be even more cost and time effective.

To sum up, the results of the study showed that benefits of including UX evaluation of the VR game even into one iteration of game design and development process could outweigh its costs. Application of UX methods to identify player experience and usability problems can assist in creating the best possible player experience. This research encourages companies to consider UX evaluation as an integral part of game development as early as on the first steps of game design process.

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Appendix 1. Findings and recommendations produced by Preliminary UX research

Crumbling factory User Experience research: Key findings

The severity ratings for the key findings were assessed based on a 4-point scale, where:

1 = Cosmetic problem; there's no real user experience impact;
2 = Minor user experience problem, fix if there's time;
3 = Major user experience problem; important to fix;
4 = User experience catastrophe; imperative to fix.

The key findings are grouped into categories and listed in the decreasing order of severity.

CF = Crumbling factory
P23 = Participant code

VR related issues

	Severity	Issue	Findings	Explanation	Recommendation
1	**4**	Wide variety of possible ill effects	• Participants claimed to experience the following effects of using VR: Blurred vision (6), Difficulty focusing (6), Dizziness (2), Disorientation (2); • P26: "People with motion sickness may feel left out."; • P3: "Movement felt disorienting.";	Even thought the side effect are temporary, those factors should be considered. Some of the most common side effects include eyestrain, nausea or virtual sickness, real-world injuries and dizziness. Feeling bad can not only affect player's mood, but also, which is important in case of CF, affect learning outcomes.	The alternative learning experience should be offered to people with permanent illnesses (for example, motion sickness). To avoid and reduce other ill effects, the visuals and mechanics of the game should be designed with caution. Different studies propose: - "In order to minimize eye fatigue and disorientation, you need a smooth and consistently high frame rate." - "Reduce mismatch between what player's eyes see and what player's proprioceptor say." For example, if the player sees a wall, there should be no way player can go through it. Because in real life player would not have this ability. If the player moves their hands, it should be displayed in the game as well. - Avoid fast movements of the players and any objects in the environment.

(continued)

					Teleportation is used for movements. - Avoid any 'horror' effects: nonlinear sounds, infrasound, expressive lighting, jump scares.
2	**3**	Hardware issues	• P4: "It takes a lot of time to get used to VR environment."; • P8: "The head set felt weird and uncomfortable first five minutes."	Some of the participants were afraid of breaking the equipment. Others were intimidating by not having their sight and feeling vulnerable.	Guidance should be provided to make players with small experience in VR feel more comfortable. Showcases and video tutorials might be the options.
3	**1**	Accessibility	• P25 had positive experience with the CF while having one hand in cast.	Unfortunately, accessibility testing was not a part of this UX research. However, implementing accessibility into the project is a need.	Further investigation on how VR in general and CF in particular affect people with visual impairments, hearing impairments, mobility impairments and cognitive impairments.

Issues with Graphics

	Severity	Issue	Findings	Description	Recommendation
1	**4**	Poor visuals	• Participants were asked to rate graphics component on the scale of 1 (very bad) to 5 (very good). The average resulting score is 2.8/5; • P7: "There is so few graphics introduced that it is impossible to define location of the experience". • P20: "The idea is good, but the current build is	Participants felt confused with the visuals or the absence of such in the CF. VR games and experiences in general rely heavily on the visual effects. Graphics is a very important part of the narrative, and lack of it significantly worsens the experience.	Considering the purpose of CF, it is necessary to provide visuals, that are realistic, trustworthy, complete the narrative and reflect the real live setup.

(continued)

			missing textures, and control panels were not even close to be realistic."		
2	**4**	Missing UI	• Less than half of the participants was able to find time tracking bars on the representation of controllers in CF; • 30% of the participants experienced difficulties with interpretation of the changes in the environment.	Absence of UI comes from poor design decisions and issues with mechanics of the experience. UI is an important tool that displays status of the system (for example, time tracking) as well as game loop, navigation, error handling, etc.	Basic UI elements must be implemented: menu, status bars, error handlers. Furthermore, elements that accompany narrative and display mechanics options should be introduced.

Issues with Mechanics and Interactions

	Severity	Issue	Findings	Description	Recommendation
1	**4**	Navigation, actions and movements are too difficult for people with no or little experience with VR	• Almost half of the participants experienced minor to major problems while executing movement and navigation actions. Half those participants in general had problems with orienting themselves. • P14: "I felt really frustrated. I take those controllers in my hands for the first time, and what? It is not intuitive,	As CF's target audience is primarily people with little experience in VR, or no experience at all, the difficulty of interactions should be adjusted by their level. Furthermore, people with no or little experience with video games tend to feel more frustrated, when they are exposed to the new environment that they supposed to explore. They are not familiar with the "wandering around" routine, they do not expect interactables (buttons, switches, ect).	Best option would be to provide a proper and detail tutorial and give the players a few minutes to get used to the environment before starting the clock. Tutorial should include explanations of what are controllers, how can they be used, what mechanics are introduced in the game. As a result, player should become comfortable within environment and aware of their exploratory possibilities in the game.

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(continued)

			and without guidance I would be really lost." • Participants with no or little experience with VR found it difficult to allocate necessary objects in the game play.		
2	**3**	Poor system visibility	• 30% of the participants experienced difficulties with interpretation of the changes in the environment • 30% of the participants experienced difficulties with visibility of the consequences of their actions • Participants were surprised every time when the game was over, as there is no visible time or score counter.	Currently there is no way to tell if the game progresses anywhere. Participants were not able to determine if their actions have any effect on the game play. System visibility and constant feedback loop are one of the key factors of good user experience.	Introduce visuals (UI, Lighting, graphics) and sounds (sounds effects, UI sounds), which are means of displaying the feedback to user's action and current state of the game. For example, if the user opens the door, the 'door opening' sound effect plays, and room lights go on.

Issues with Audio

	Severity	Issue	Findings	Description	Recommendation
1	**4**	Absence of audio system	CF currently does not offer any audio system. Participants expressed the opinion that audio effects could have enhanced the experience greatly.		Introduce audio system which would include background game play music, UI sound effects, sound effect).

(continued)

Issues with Game Play and narrative

Game play and its playability are characterized by satisfaction, learning, efficiency, immersion, motivation, emotion and socialization.

	Severity	Issue	Findings	Description	Recommendation
1	**4**	Unclear game setting and narrative	• Only 30% of participants were extremely or at least fairly interested in the game's story; • Participants were not able to determine settings and rules of the game;	Settings and narrative are milestones of every game. Those are the factors that make players engage within the game. In case of CF, participants were not provided with any visual and sound clues. Therefore, no participant was able to complete the experience without further explanations and instruction from the facilitator.	Extra work on the narrative of the game should be done. Visual and audio clues must be implemented according to the redesigned narrative. Tutorials and clear rules must be offered to the player throughout the game.
2	**4**	Unclear game loop	• P11: "The game was short and simple"; • P12: "Not so many things to explore"; • P21: "I wasn't able to progress"; • Only few participants with advanced understanding of VR games were able to stabilize the factory;	CF does not offer players any progression loop. There is also no possibility to adjust the level of difficultness for the game. Participants felt either bored (if they are of some experience with VR) after one game cycle or frustrated (if use VR for the very first time).	Implement level system and win state, set clear goals for the player.
3	**3**	Poor motivation	• "I felt unmotivated. There were no guidelines."; • Participants were asked to rate motivation component on the scale of 1 (very bad) to 5 (very good). The average resulting score is 2.2/5;	Motivation is a key factor in game engagement and learning. Higher motivation means player being more involved in their actions, which leads to better learning outcomes.	Behavioural change may be introduced via PBL (points, badges, leader boards). Right narrative and setting can also play a positive role in promoting higher motivation.

(continued)

4	**2**	Concerns about learning outcome	• P18: "Body movement in a real-life situation differs widely so I believe the game might be useful to train in understanding the tasks in theory (what to do) but not so much in the practical sense of knowing-how."	Although in general participants with initially little or no experience with VR felt more comfortable with the technology after CR, some claimed that CR did not provide enough learning opportunities and movement techniques for participants to feel themselves advanced.	Achieving greater learning outcomes requires re-evaluation of learning techniques that may be used in the experience. The set of mechanics should be widened.
5	**1**	Average assessment rates on several game elements	• Participants were asked to rate several game elements on the scale of 1 (very bad) to 5 (very good). The average resulting score for engagement, challenge and emotional attachment is in the 2.8-3.0/5 range. • Average answers on: "I enjoyed it", "I felt that I could explore things", "I felt successful", "It was aesthetically pleasing".	Although the data does not show any major UX thread on those game elements, improvements may be done to enhance the experience.	Research on techniques to promote engagement and emotional attachment in the games.

Appendix 2. Player experience evaluation questionnaire

Evaluation of User Experience of Crumbling Factory

General information

* Required

1. **Age** *

Mark only one oval.

- ◯ 18-22
- ◯ 23-25
- ◯ 26-30
- ◯ 30+

2. **Educational Background (the last completed or in progress)** *

Mark only one oval.

- ◯ High school
- ◯ College
- ◯ College degree
- ◯ Master's/Advanced degree
- ◯ Other: _____

3. **Employment Status** *

Check all that apply.

- ☐ Part-time
- ☐ Full-time
- ☐ Unemployed
- ☐ Student

4. **I consider my experience with VR technology to be ...** *

Mark only one oval.

	1	2	3	4	5	
Extremely poor (never interfered)	◯	◯	◯	◯	◯	Extremely advanced (worked on creating VR experiences or games)

5. **I consider myself an active member of the game community and/or a gamer** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	True to the extreme extent

VR related ill effects

Answer only if you have experienced some negative effect(s) while playing the game.

6. **I felt..**
Check all that apply.

- [ ] Nausea
- [ ] Difficulty concentrating
- [ ] Dizziness
- [ ] Headache
- [ ] Drowsiness
- [ ] General discomfort
- [ ] Boredom
- [ ] Fatigue
- [ ] Tired eyes
- [ ] Eyestrain
- [ ] Blurred vision
- [ ] Difficulty focusing
- [ ] Sore/aching eyes
- [ ] Other: _____

Core module

7 **Please i dicate how you felt while playing the game for each of the items on the following scale:** *

Mark only one oval per row.

was nterested n the game's story					
I thought it was fun					
I was fully occupied with the game					
I felt happy					
It gave me a bad mood					
I thought about other things					
I found it tiresome					
I felt competent					
I thought it was hard					
It was aesthetically pleasing					
I forgot everything around me					
I felt good					
I was good at it					
I felt bored					
I felt successful					
I felt imaginative					
I felt that I could explore things					
I enjoyed it					

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	not at all	slightly	moderately	fairly	extremely
I felt content					
I felt skilful					
I was fast at reaching the game's targets					
I felt annoyed					
I felt pressured					
I felt irritable					
I lost track of time					
I felt challenged					
I found it impressive					
I was deeply concentrated in the game					
I felt frustrated					
It felt like a rich experience					
I lost connection with the outside world					
I felt time pressure					
I had to put a lot of effort into it					

Post game module

8 **Please i dicate how you felt after you finished playing the game for each of the items on the following scale:** *

Mark only one oval per row.

	not at all	slightly	moderately	fairly	extremely
I felt revived	◯	◯	◯	◯	◯
I felt bad	◯	◯	◯	◯	◯
I found it hard to get back to reality	◯	◯	◯	◯	◯
I felt guilty	◯	◯	◯	◯	◯
It felt like a victory	◯	◯	◯	◯	◯
I found it a waste of time	◯	◯	◯	◯	◯
I felt energised	◯	◯	◯	◯	◯
I felt satisfied	◯	◯	◯	◯	◯
I felt disoriented	◯	◯	◯	◯	◯
I felt exhausted	◯	◯	◯	◯	◯
I felt that I could have done more useful thing	◯	◯	◯	◯	◯
I felt powerful	◯	◯	◯	◯	◯
I felt weary	◯	◯	◯	◯	◯
I felt regret	◯	◯	◯	◯	◯
I felt ashamed	◯	◯	◯	◯	◯
I felt proud	◯	◯	◯	◯	◯
I had a sense that I had returned from a journey	◯	◯	◯	◯	◯

Game elements

9. **Rate the following elements** *
Mark only one oval per row.

	very bad	poor	fair	good	excellent
Motivation					
Engagement					
Challenge					
Emotional attachment					
Learning outcome					
Story/Narrative					
Theme and setting					
Interactions and control					
User Interface					
Graphical elements					
Sound					

Research question evaluation

10. **Did Crumbling Factory help you to get familiar and more comfortable with Virtual Reality Technology?** *
Mark only one oval.

- Not at all
- Slightly
- Moderately
- Fairly
- Extremely

11 **How ca you evaluate your experience with Crumbling Factory?** *
Mark only one oval.

- Very bad
- Poor
- Fair
- Good
- Excellent

Comment section (optional)

12. **If you have any additional comment regarding your experience with Crumbling Factory and/or this survey, please, feel free to express them.**

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Appendix 3. Detailed score-per-item comparative table that includes Core Module, Post-Game Module and Game elements assestment

No	Item	Version One (v1)	Version Two (v2)	Difference (v2 – v1)
Core Module				
1	I felt content	1,8	1,7	-0,1
2	I felt skilful	1,7	1,4	-0,3
3	I was interested in the game's story	1,4	2,1	0,7
4	I thought it was fun	2,3	2,9	0,6
5	I was fully occupied with the game	2,6	3,8	1,2
6	I felt happy	2,1	2,1	0,0
7	It gave me a bad mood	0,0	0,5	0,5
8	I thought about other things	0,8	0,4	-0,4
9	I found it tiresome	1,1	0,8	-0,3
10	I felt competent	1,8	1,4	-0,4
11	I thought it was hard	1,9	2,4	0,5
12	It was aesthetically pleasing	1,9	2,2	0,3
13	I forgot everything around me	1,9	2,7	0,8
14	I felt good	2,0	2,1	0,1
15	I was good at it	1,3	1,2	-0,1
16	I felt bored	0,5	0,1	-0,4
17	I felt successful	1,7	1,4	-0,3
18	I felt imaginative	1,4	1,1	-0,3
19	I felt that I could explore things	2,1	2,0	-0,1
20	I enjoyed it	2,5	2,9	0,4
21	I was fast at reaching the game's targets	1,5	1,0	-0,5
22	I felt annoyed	0,7	1,1	0,4
23	I felt pressured	0,6	1,8	1,2
24	I felt irritable	0,1	0,6	0,5
25	I lost track of time	0,8	2,5	1,7
26	I felt challenged	1,9	2,8	0,9
27	I found it impressive	2,5	1,9	-0,6
28	I was deeply concentrated in the game	2,4	2,8	0,4
29	I felt frustrated	0,8	1,1	0,3
30	It felt like a rich experience	1,6	1,7	0,1
31	I lost connection with the outside world	1,3	1,9	0,6
32	I felt time pressure	1,6	2,7	1,1
33	I had to put a lot of effort into it	2,1	2,3	0,2

Post-Game Module				
1	I felt revived	0,9	1,1	0,2
2	I felt bad	0,2	0,3	0,1
3	I found it hard to get back to reality	0,0	0,7	0,7
4	I felt guilty	0,0	0,2	0,2
5	It felt like a victory	0,7	1,4	0,7
6	I found it a waste of time	0,2	0,4	0,2
7	I felt energised	0,6	1,6	1,0
8	I felt satisfied	1,2	2,3	1,1
9	I felt disoriented	0,3	0,8	0,5
10	I felt exhausted	0,1	0,5	0,4
11	I felt that I could have done more useful things	0,1	1,0	0,9
12	I felt powerful	0,5	1,1	0,6
13	I felt weary	0,1	0,5	0,4
14	I felt regret	0,0	0,2	0,2
15	I felt ashamed	0,0	0,1	0,1
16	I felt proud	0,8	1,2	0,4
17	I had a sense that I had returned from a journey	0,1	1,8	1,7