Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

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The effects of a collaborative Virtual Reality application in Norwegian language learning and teaching for immigrants with at least secondary education

Master's thesis in Informatics
Supervisor: Monica Divitini and Ekaterina Prasolova-Førland
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Abstract

This study aims to see the effects of collaborative Virtual Reality on Norwegian language teaching and learning. The focus group is immigrants with at least secondary education and Norwegian language teachers. Immigration and integration is an important process in Norway, where participation in the job market is seen as a vital route for integration. At the same time, competency in the Norwegian language and familiarity about the Norwegian culture are important preconditions to enter the job market and education system. At the same time, Virtual reality has found success and has gained popularity within training and education.

With the design and creation research method, a Virtual Reality application was developed using the Scrum agile framework and user-centred design. Studies have found that a constructivist approach works best with Virtual Reality. Social-constructivism and experiential learning has therefore been inspirations for the learning content. Most of the related works does not include the teacher, and their role in such an application is unknown. To answer this, we cooperated closely with teachers during development. This resulted in an application immersing users in a virtual environment customised by a teacher, where students can collaborate in completing task-based instructions.

The findings show that there is interest and potential in the application. There were signs of a strong feeling of immersion, increased motivation and a change in the social hierarchy between teachers and students. On the other hand, some participants felt it was more difficult to stay focused compared to a regular classroom and learning outcome could not be measured sufficiently. Further work should look into more thorough evaluations on the effects of the virtual environment, communication through the virtual avatar and the learning outcome from the application.

Acknowledgements

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In addition, we would also like to thank all language teachers that has been a part of this project. Your expertise has been crucial for this research. We also extend our gratitude towards the students who volunteered for user testing with us, the feedback we received has truly been valuable.

Lastly, a thank you to Unity and Photon for the technical support they provided us when we were in need during the development.

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Abbreviations

AI	=	**A**rtificial **I**ntelligence
API	=	**A**pplication **P**rogramming **I**nterface
DC4LT	=	**Digital C**ompetences for **L**anguage **T**eaching
GDPR	=	**G**eneral **D**ata **P**rotection **R**egulation
HMD	=	**H**ead **M**ounted **D**isplay
IDI	=	**I**nstitutt for **D**atateknologi og **I**nformatikk (Department of Computer Science)
ISFiT	=	The **I**nternational **S**tudent **F**estival **i**n **T**rondheim
MMORPG	=	**M**assively **M**ultiplayer **O**nline **R**ole **P**laying **G**ame
NKUL	=	**N**asjonal **K**onferanse om bruk av IKT i **U**tdanning og **L**æring (National Conference about the usage of IT in Education and Teaching)
NPC	=	**N**on-**P**layable **C**haracter
NSD	=	**N**orsk **S**enter for Forsknings**d**ata (Norwegian Centre for Research Data)
NTNU	=	**N**orges **T**eknisk-**n**aturvitenskapelige **U**niversitet (Norwegian University of Science and Technology)
PUN	=	**P**hoton **U**nity 3D **N**etworking
SSB	=	**S**tatistisk **S**entral**b**yrå (Statistics Norway)
UI	=	**U**ser **I**nterface
VR	=	**V**irtual **R**eality

Chapter 1

Introduction

This project is about the use of Virtual Reality (VR) and collaboration in teaching Norwegian as well as the implementation of such an application. This chapter will introduce the context, research questions and the application concept.

1.1 Context

This project was done by two students as a master thesis part of a master's programme in Informatics: Interaction Design, Game and Learning Technology at the Norwegian University of Science and Technology (NTNU). It was completed in association with the Department of Computer Science (IDI) and the Digital Competences for Language Teaching (DC4LT).

In the duration of the project, we have collaborated with the Virtual Reality labs at NTNU Gjøvik, Norwegian teachers at NTNU Dragvoll, a local High School: Lukas vgs in Trondheim as well as several internal students and professors at IDI.

Over the course of September 2018 - June 2019, we researched, developed and evaluated a new VR application to be used in teaching Norwegian for immigrants with at least secondary education and will present the findings in this document.

1.2 Research motivation

We started to read about our topic by going through reports and studies about immigrants and language learning. Many reports were from Statistics Norway (SSB) where they have gathered data about immigrants coming to Norway, their backgrounds, income and reason for immigration. The reports also explained details about the introduction programme

which is the greatest political integration measure in Norway [1]. This programme includes Norwegian language training and learning about Norwegian culture. It is also mentioned that the number of immigrants and Norwegian-born citizens with immigrant parents tripled between 2007 and 2017. The introduction programme was started in 2004 and the goal was that 70% of the participants would be employed or take up studies within one year after the programme was over. In 2015 this goal was not achieved according to the report where only 58% was either employed or have taken up education. However, it should be noted that 31% had an unknown status, which might indicate that the the percentage might be higher than the 58% recorded.

Overall, there is an agreement between both scientists and politicians that the best route for integration is through participation in the job market. However, competency in the Norwegian language and familiarity about the Norwegian society are important preconditions to get into the job market and education system [2]. Great effort is being done for this to be possible, the introduction programme being one of them.

Several studies show that Virtual Reality works well in constructivist activities [3] [4]. Experiential learning in particular, a constructivist method, seemed relevant for a project similar to what we were aiming for. Games and simulations in learning builds on the constructivist methods and has a long time been used with success. Psotka [5] explains this is because it introduces challenge, interactivity, realism, fantasy, cooperation and immersion, which are all important in experiential learning.

In addition to being just a game, VR also improves teaching by "[replacing] interaction with immersion, the desktop metaphor with a world metaphor, and direct manipulation with symbiosis" [5]. This theory will be further explained in Section 2.3. Studies also show that knowledge and experiences gained in VR has a better retention than simulations and other games [6], not to mention that one can simulate any situation at any location. Finally, Wehner, Gump, and Downey [7] found that "[...] virtual worlds could be a valuable resource to lower student anxiety and increase their motivation to learn a foreign language".

During development, we found a lack of research done on the teacher's role in VR. Lin and Lan [3] confirms this, as they point out the most effective role of the teacher in a virtual language environment has not yet been found, and there being a research gap concerning how the instructors' roles changes in a VR classroom.

1.3 Problem Definition

After conducting observations and sending out surveys, we landed on a user group of immigrants with at least secondary education learning Norwegian. The problems we want to address involve the pronunciation of Norwegian words, increasing students' Norwegian vocabulary and practising the language outside the classroom. Later, we also added the teacher's role to our problem definition.

In the end, we arrived at a list of user needs and requirements for the application. These results can be seen in Table 4.3, Table 4.4 and Table 4.5, but in short they explain the needs previously presented.

Defining this problem was the driving force of the first part of this project, this process is elaborated in Chapter 4.

1.4 Research Questions

The research questions given below aims to give insight into how a VR application can be used to support both Language teaching and learning to adult immigrants with at least secondary education. This also includes how one would go to develop such an application, interaction between users and the teacher's role in this new environment.

RQ1 How can a collaborative Virtual Reality application support the language learning of adult immigrants with at least secondary education in Norway?

- RQ1.1 What challenges are there in Norwegian language learning for immigrants with at least secondary education in Norway?
- RQ1.2 How does the context of the virtual environment setting influence language learning?
- RQ1.3 To what extent does a Virtual Reality application influence the user's motivation towards language learning?

RQ2 What is the relationship between the teacher and students when using virtual avatars in a VR Language Learning application?

- RQ2.1 What is the teacher's role in such a VR application?
- RQ2.2 How does having a virtual avatar influence the social interaction between people in such a VR application?

RQ3 How can one develop an immersive and collaborative VR application for Norwegian language learning?

- RQ3.1 What requirements would such an application need to answer the challenges faced in Norwegian language teaching for immigrants with at least secondary education in Norway?
- RQ3.2 How can one implement a VR application answering these requirements?

1.5 Research Method

The research method we used was the design and creation strategy, as explained by Oates [8]; following the five steps: awareness, suggestion, development, evaluation and conclusion. This was chosen as it fits for developing new IT-systems, and we tried to develop a new IT-system to our chosen domain. In addition, to gather both qualitative and quantitative data, we performed interviews and questionnaires in the evaluation phase of the application.

The research is reported to the Norwegian Centre for Research Data (NSD) and follows their guidelines. All data collected during this project were anonymous according to EU's General Data Protection Regulation (GDPR) [9]. Voice recordings from interviews were recorded with a dictaphone and the interviewees signed a consent form explaining their rights and our intentions, this form can be seen in Appendix A.1. We did not have consent forms for the questionnaires, but they received information of their rights, our intentions and the data being anonymous.

Beginning with the awareness step, we gained insight into the current situation and the users' needs through observations and surveys, elaborated in section 4.2 and 4.3. This whole process is explained more thoroughly in chapter 4. This was done in addition to reading other studies on the topic as well as related works, which is explained in Chapter 2 and Chapter 3.

Then we designed a tentative suggestion of a system to be developed to help the needs we found. The suggestion is described in Section 1.6.

Development was done using Scrum [10] as the development method and user-centred design [11]. To combine these two, we planned three week sprints, where the last week of each sprint consisted mainly of testing with users and discussing with them what they wanted to see in the finished product. This is further explained in Chapter 5.

The final evaluation was done using questionnaires for the students both before and after they tried the application in a Norwegian lesson together with a teacher. In addition to the student survey, we performed semi-structured interviews with the teachers. More detail of the design and completion of these evaluations, as well as the results, can be seen in Chapter 6.

Finally, we conclude with a discussion in Chapter 8.

1.6 Virtual Reality language learning application

The application went through several iterations of changing concepts and design, this process is described in Chapter 5. This was mostly as a result of the constant involvement of users, as they would often bring up great suggestions and variations.

The finished version is a VR tool for teachers to use in classes. Teachers are placed together with their students in either a Norwegian forest or café, where the teacher can customise their sessions and create task-based instructions. Several interactable objects can be placed in the world, each having their Norwegian word written on them when picked up and an auditory cue on their pronunciation. Users in the virtual space can communicate with each other using spatial voice chat as well as simple hand gestures and body language.

Source code for the finished application can be found at:
"https://github.com/kaktusgris/Language-Teaching-VR/".

1.7 Thesis Structure

This thesis consists of seven chapters, which will each be described here in this section.

Chapter one introduces the problem and application as well as the motivation behind these choices and the context around it.

Chapter two goes into the background of both language pedagogy and virtual reality technology.

Chapter three puts forward similar applications for collaborative language teaching in VR or otherwise and relevant studies done on them.

Chapter four describes the awareness process in the design and creation strategy: what we learned when obtaining information about the status quo. Finishing with a list of the user needs and system requirements.

Chapter five follows the development process from beginning to end and explains changes made during the development. It also describes the various usability tests done as well as other tests.

Chapter six contains the evaluation and results, both the ones made during the final evaluation as well as the ones made during development.

Chapter seven discuss the findings and presents limitations of the research.

Chapter eight contains a conclusion of the thesis and suggestions for future work.

Chapter 2

Background

This chapter will present the history of, as well as concepts that are important for VR, methods and theory of language teaching and the use of VR in language teaching.

2.1 Virtual Reality

In this section, we will give a brief overview of the history of VR, its definition, and concepts related to it. At the end, we will discuss the technology that is being used now and what will be used in the project.

2.1.1 History of VR

According to Jerald [12], one can trace the roots of VR all the way back to the 1800s. The term itself was coined by Jaron Lanier around the 1980s and at that time the interest for the field was rising. It was not until 1996 that the industry met its peak and started to fall. This started the "VR winter" which took place in the first decade of the 21st century. After some time, interest began to rise once again. The defining moment was when the Oculus Rift Kickstarter was created in 2012. The media caught on and several companies were now willing to invest on the industry once again. This included Facebook which acquired Oculus VR in 2014 for $2 billion. The technology is still at an early phase, but has been growing ever since, getting more accessible and therefore reaching more people and in turn getting more use cases [12].

2.1.2 Definition of VR

In 1992, Steuer [13] brought up the issue of defining VR in terms of its hardware and wanted to give a definition that could be related to other medias. Steuer wanted to involve two concepts in the definition: presence and telepresence. Presence is defined as the sense

of being in an environment, while telepresence is how one experiences presence in an environment through a communication medium. Building upon these two concepts he defined VR as:

> A "virtual reality" is defined as a real or simulated environment in which a perceiver experiences telepresence.

That definition was made in 1992, a more recent definition from 2015 is by Jerald [12]:

> Virtual reality is defined to be a computer-generated digital environment that can be experienced and interacted with as if that environment were real.

Both definitions give a general meaning to VR, though the more recent one mentions a "computer-generated digital environment that can be experienced and interacted with", which is more relevant to our project and the one we will use.

2.1.3 Immersion

An important property to VR is the issue of immersion. According to Jerald [12] immersion is an objective degree of how a VR system can give the users a sensory experience that is extensive, matching, surrounding, vivid, interactive and plot informing. It is considered to be something that has the potential to engage users; a force that leads the mind of the user through the VR experience.

The feeling of immersion is also related to the type of technology being used. Mazuryk and Gervautz [14] describes three levels of immersion: desktop VR, fish tank VR and immersive systems. The descriptions of these systems are summarised in Table 2.1. We will be working with immersive systems as we make use of a Head Mounted Display (HMD) and controllers that will be explained further in Section 2.2. When using the term VR further in this thesis, we are referring to immersive virtual reality, unless stated otherwise.

VR system	Description
Desktop VR	Makes use of a monitor to display images of the virtual world and no support for sensory output. This is the simplest type of VR application.
Fish tank VR	An improvement that was made on the desktop VR. The system supports head tracking and improves the feeling of presence. Though it still makes use of standard monitors and generally does not support sensory outputs.
Immersive systems	Uses a HMD to totally immerse users in a computer generated world that supports stereoscopic viewing according to the user's orientation and position. This kind of system can be further supported with audio, haptic and sensory interfaces.

Table 2.1: Descriptions of the different VR systems.

2.1.4 Place-presence, Co-presence and Social-presence

Bulu [15] mentions that presence and satisfaction are two important factors for learning in virtual environments. She describes presence as the sense of "being there", meaning that a user will response to "there" as if it were real. How involved the user is in the environment and the level of immersion will affect how they perceive presence. Bulu calls this type of presence as place-presence and extends it to two more types: social-presence and co-presence. These three types are summarised in Table 2.2.

Type of presence	Definition
Place-presence	An individual's sense of being in an environment.
Social-presence	Perception of the medium's ability to connect people to each other and creating a sociable, warm, and intimate interaction.
Co-presence	Participants are mutually aware that they share a physical environment.

Table 2.2: The different types of presence as described by Bulu.

Bulu questions both the relationship the different types have among each other and their connection to satisfaction. She concludes that some literature conflict each other when speaking about the connection between the different types and satisfaction [15]. At the same time, there seems to be a tendency for social-presence to affect satisfaction while immersion is affected by place- and co-presence. Nonetheless, the role of presence is important and these different types are something must be taken into account when working with VR.

2.1.5 Collaboration

Merriam-Webster defines collaboration as "to work jointly with others or together especially in an intellectual endeavor" [16]. Collaboration can also be seen as an element of an application which builds upon different factors. Kraut et al. [17] says that there are three factors that are relevant for collaboration and are all related to each other, these are: proximity, communication and awareness.

Proximity can be seen as a combination of co-presence and place-presence, which has already been mentioned in Section 2.1.4. Kraut also says that proximity is an important factor as it leads to encounters, which in turn urges communication. With collaboration, long distances are seen as a drawback, because it makes it difficult to work together. There is a certain relationship between communication and proximity that is important to consider. This relationship can be described by making use of the affordances listed in Table 2.3. Though, not all of these affordances might be fulfilled in VR. For example, VR often mimics real life and uses voice chat for communication. This is, in most cases, a form of communication that does not support reviewability and revisability.

At the same time, proximity is an advantage that VR often has as it can create a strong feeling of presence if done correctly. This feeling of being close to each other can also

Affordance	Definition
Audibility	Participants can hear other people and sounds in the environment.
Visibility	Participants see other people and objects in the environment.
Tangibility	Participants can touch other people and objects in the environment.
Co-presence	Participants are mutually aware that they share a physical environment.
Mobility	Participants can move around in a shared environment.
Co-temporality	Participants are present at the same time.
Simultaneity	Participants can send and receive messages at the same time.
Sequentiality	Participants take turns, and one turn's relevance to another is signalled by adjacency.
Reviewability	Messages do not fade over time and can be reviewed.
Revisability	Messages can be revised before being sent.

Table 2.3: A list of affordances by Kraut.

apply even when not being in the same physical space. Meaning that the component of proximity can be found, regardless of the actual distance between users.

Finally, with awareness, we will be using the definition by Gutwin and Greenberg [18] which says that awareness is "knowledge created through interaction between an agent and its environment – in simple terms, knowing what is going on".

2.1.6 Design principles for VR

Jerald [12] says that the most important part of interaction in VR is the person doing the interacting and suggests using human-centred design when creating content for VR. Human-centred design is focused on the human side of communication between user and the machine, in other words: designing the interface from the user's point of view. In essence, the goal for the design is to create an intuitive interface. Intuitiveness is in the mind of the user and is about how quickly a user can understand an interface. A designer can use an interaction metaphor to convey intuitiveness. An interaction metaphor is an interaction concept which exploits specific knowledge that users have of other domains. There are also other design principles that can aid with supporting intuitivity, with Norman's principles [19] being one of the most used. These principles are summarised in Table 2.4.

The interactions that are done in a VR application often simulate actions that can be done in real life. For example, a door in VR will most likely look like, have the same affordances and act similar as a door in real life. However, VR is not limited by the constraints of reality, one can for example shrink oneself and explore the inside of the human body or traverse Mt. Everest from the comfort of one's own living room. Designing the interfaces for these experiences is where user-design in VR becomes challenging. Our own design and how we followed these principles are explained in Chapter 5.

Principles	Definition
Affordance	The property of a thing that defines what actions a user can perform and how they can interact with it. In a simpler term, it is a relationship between what a user can do and the properties of a thing.
Signifier	Connected to affordances, a signifier is a perceivable indicator that tells the user about the purpose, operation and behaviour of an object.
Constraint	A design constraint is a limitation on actions and behaviours to simplify interaction while improving accuracy, precision and user efficiency.
Feedback	A form of communication that tells the user of the result of an action or status of a task. This is to help them understand the state of whatever they are interacting with and help them with future decisions.
Mapping	A relationship between two or more things. Users learn this best when the relationship is obvious and understandable between controls, actions and intended results.

Table 2.4: Different concepts and principles that are related to human-centred design

Virtual characters

Another important consideration is the look and feel of the characters in a virtual environment. Jerald [12] points out two types of characters in a virtual environment: the agent and the avatar. An agent is a computer-controlled character while an avatar is a character that is a virtual representation of a real user. It is with the avatar that users can experience the virtual world and can be represented in many different ways, which makes it possible for experiences through different roles and perspectives [20].

One appearance that is effective to use is a caricature representation of a person. Meaning the representation or characteristics are exaggerated, and small details are omitted or simplified to create a comic or grotesque effect [12]. The reason for this being effective is because of a concept called “the uncanny valley”. The concept is also discussed in the field of robotics and is seen as a relationship in design between a product with human likeness and people’s affinity towards it [21]. The main idea is that there is a certain point, when something gets closer to looking human, where our perception shifts from empathy to revulsion. This relationship is illustrated in Figure 2.1.

Having a virtual avatar representing the users is especially important for us, as Wehner, Gump, and Downey [7] explains that people are locked in their own identities and used to existing social standards in regards to language learning. They suggest that having an avatar, a new identity, opens up for accepting new knowledge and social constructs. Further stating that the anonymity of the avatar allows “communication unrestricted of visual cues like gender, race and ethnicity”.

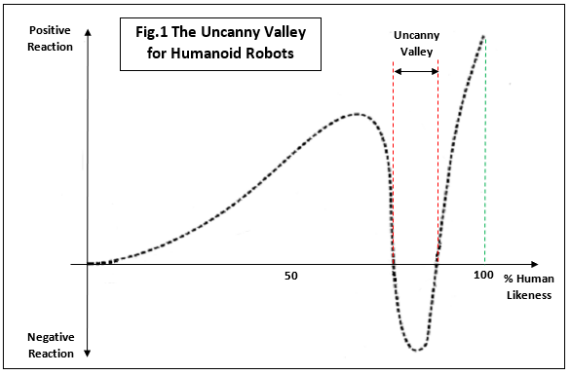


Figure 2.1: A graph showing the uncanny valley, visualising the relationship between human likeness and people's reaction.

2.2 State of the Art

This section will give a brief overview of the state of VR technology and specifically what we will be using in this project. We will be focusing on Immersive VR systems, as was defined in Table 2.1. Today there are many VR technologies being developed and used, such as: the HTC Vive, Oculus Rift, PlayStation VR, Samsung Gear VR, Windows Mixed Reality, and Google Daydream to mention a few. Though they all make use of an HMD, they vary in complexity and quality. For example, the Samsung Gear VR and Google Daydream is simpler, using a smartphone to display VR applications. This means it is more limited as to what it can do, in comparison to the HTC Vive, where you also have controllers to interact with the virtual world. On the other hand, the price for simpler devices are often lower, making them more accessible. This variation in simplicity gives different degrees of immersion, and in turn: presence, as explained in Section 2.1.4. Table 2.5 summarises the aforementioned hardware.

These are some of the most popular VR hardware available on the market, but there are many more out there. In addition to this, there are several external components that can be added to some of these systems to increase immersion. Components such as: treadmills, motion platforms, and passive and active haptics [12]. What we mainly used in our project was the HTC Vive and will therefore go into further details about the system. The components that make up this VR system is an HMD, two base stations and two controllers, see Figure 2.2. The HMD is connected to a PC with cables and a link box in between them. The base stations are placed diagonally in opposite corners of the room that will be used as the play area. The base stations track the controllers and HMD, mapping things such as location, height and rotation to the virtual world.

Recently, the Vive pro has been released and our application can be used seamlessly with both systems, see Figure 2.3. The Vive pro offers improvements in many areas: the screen has a higher resolution with a 37% increase in pixels per inch, hi-res audio and a more balanced weight distribution to make it more comfortable. They also come with new base stations intended for multi-user VR, increasing the play area and improved tracking.

VR hardware	Description
Google Daydream	Similar to Samsung Gear VR, Google daydream makes use of a smartphone for VR experiences. In addition, it also has a standalone version that does not need any cables, PC, smartphones or external sensors [22].
Samsung Gear VR	A headgear that makes use of a smartphone to display and simulate a VR experience. It comes with a controller to enhance interaction with menus and simple controls [23].
PlayStation VR	This VR system is a VR headset developed to be compatible with the PlayStation 4 video game console. It has a 1080 display resolution and tracks 360 degree head movement. This is done with help of a camera with dual lenses and 3D depth sensors. It also comes with different controllers for interaction with the VR space [24].
Oculus Rift	The Oculus Rift features high fidelity graphics, tracked hand controllers and full room-scale support with sensors that translates movement into the VR space whether one is seated or moving about [25].
HTC Vive	A fully immersive VR system that has a room-scale stage, 360-degree controller and headset tracking, and a chaperone system that warns you of the boundaries of the play area. It also has high resolution graphics, directional audio, a built-in microphone and haptic feedback [26].

Table 2.5: Descriptions of different VR hardware.

Figure 2.2: The HTC Vive with controllers, base stations and the HMD

Figure 2.3: The HTC Vive pro

Figure 2.4: The Oculus Rift

After the release of the Vive pro, another product came out that would increase mobility: the Vive wireless adaptor. With the wireless adaptor, the HMD no longer needs a connection to a PC. However, it still has a small cable connected to a power bank attached to your person. Meaning, it is not complete freedom of movement as one still has to be aware of the power bank, but it is still a significant improvement.

During some of the final evaluations of our application, the Oculus Rift was used. It is similar to the HTC Vive in many cases, but it uses two sensors sitting on the table in front of the user instead of in the corners of the room. Having only sensors sitting on the table in front of the user, means the user cannot stand with their back to the sensors, it also struggles with tracking the floor. But it is easier to transport and takes up less physical space than the HTC Vive. The Oculus Rift hardware can be seen in Figure 2.4.

2.3 Language Teaching and Pedagogy

In this section, we will go over some methods and movements in language pedagogy, with focus on subjects we found relevant to VR. This theory inspired the choices made when designing and developing our application.

2.3.1 History of Language Pedagogy

Pedagogy is by many not seen as a science, Radosavljevich [27] lists up some reasons why, such as: ”it has not a domain of its own, it borrows from other sciences” and ”it can not formulate general principles which are universal”. His second point is especially prevalent, as the methods used in language teaching has changed over time, and even today the practice varies from practitioner to practitioner [28]. This disagreement causes the experts to have different opinions on what is the ”correct way” to do things, methods fluctuates and are reinvented all the time corresponding with the shift to postmodernism [29].

As an example, Pishghadam and Mirzaee [29] delve into what effect this move from modernism to postmodernism have had on the methods used in language teaching. In general, they conclude that the modernist way of thinking, where there exists a ”best” way of doing things, has been replaced with the postmodern ideology of everyone being different and has different experiences. They also state that there is a shift from instructivism to constructivism: a shift from teaching by imposition to teaching by negotiation.

Pishghadam and Mirzaee goes on to explain instructivist methods thinking of learners as “reactive beeings” either accepting or rejecting the material offered by the teacher. Constructivist methods, on the contrast, sees learning as a highly subjective, autonomous and active process. Constructivist methods often include interactive forms of work such as collaboration and project work.

In addition to social constructivism and experiential learning, mentioned in Section 2.3.2 and Section 2.3.3 respectively, two prominent methods have been found to be relevant to this project: audio-lingualism and task-based instruction.

Audio-lingualism, has focus on the oral and informal language compared to the grammar translation’s focus on the written, formal language. It then promotes speaking and listening to the language and learning it as you would a skill such as an instrument. An instructivist method [28].

Task-based instruction is based on assumptions that language is fundamentally a way of communication and try to teach languages by letting the students communicate with scenarios with less of a focus on actual correct sentences but rather on successful communication. A constructivist method [28].

2.3.2 Social constructivism

According to Kalina and Powell [30], constructivism is both a vague and popular teaching method. It is centred around the learner and has two major types: cognitive constructivism and social constructivism. With cognitive constructivism being more focused on individuals through personal process, while social constructivism is about constructing ideas through interaction with the teacher and other students. It is social constructivism that we

are most interested in and it is based on a theory by Vygotsky. The theory makes three main assumptions [20]:

1. Reality is not discovered and does not pre-exist, but is constructed through human activity.

2. Knowledge is a product of human interaction, socially and culturally created.

3. Learning is a social and active process, taking place when individuals partake in social activities.

Educational or learning models based on this theory will emphasise collaboration among learners and educators. An example of such a model is "Active Learning", which is an approach placing responsibility on learners by having them work in pairs or groups while working with the material [20]. Some of the activities that can be used with the model is: role playing, active discussion or debates, learning by teaching exercises, and other forms of cooperative learning.

2.3.3 Experiential Learning

Kolb [31] presents a new pedagogical method following the dramatic change in the concept of learning at the end of the 20th century; of teacher not as purveyors of knowledge and learners as passive receivers, but rather a more constructivist approach where the learners are more active in their own learning and the teachers being more of a facilitator. He calls this method for experiential learning, which Lewis and Williams [32] later describes as follows:

> "In its simplest form, experiential learning means learning from experience or learning by doing. Experiential education first immerses adult learners in an experience and then encourages reflection about the experience to develop new skills, new attitudes, or new ways of thinking."

Lewis and Williams [32] also lists two additional motivations for experiential learning. First, the increase of adult learners who wants to use their previous experiences when learning. Second, the demand for flexibility and better capacity for leveraging previous knowledge and experiences in a new way. This is especially true, as experiential approaches appear to be more effective when teaching skills employers are looking for, such as: communication skills, the ability to work in teams, and workplace literacy.

Kolb [31] introduces a model explaining that the learner's learning experience is a cycle consisting of observations, formation of concepts, testing implications of concepts and concrete experience. He called this the experiential learning model and can be seen in Figure 2.5. The model illustrates that people learn best by first having a here-and-now experience, followed by a collection of data and observations about that experience. These observations are then analysed before being made into conclusions. The process then feeds back into itself by the user using this new knowledge in their next experiences [31].

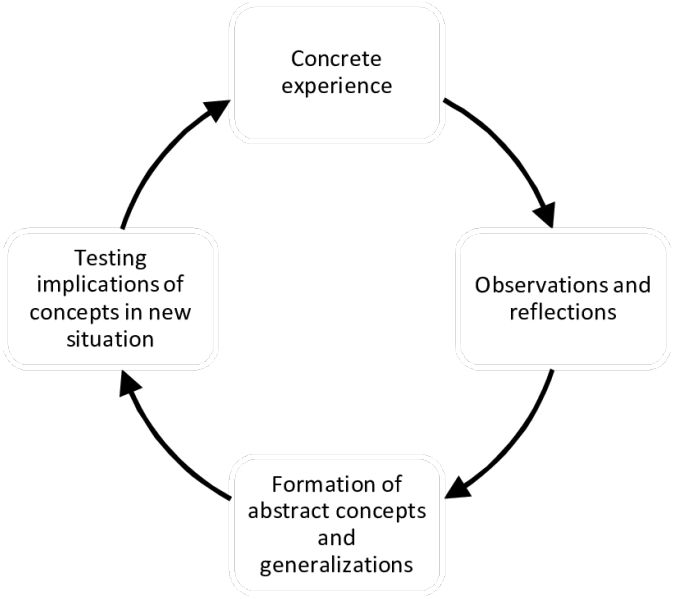


Figure 2.5: Kolb's Experiential Learning Model.

The Experiential Gaming Model

Kiili [33] builds on the theory of experiential learning and applies it in serious games. One of the main reasons to use game elements in learning is to enhance motivation and as Kiili explains "getting into the flow". He describes flow as "a psychological state where [the user] is so involved with the goal driven activity that nothing else seems to matter"[33]. This sense of flow is an important aspect in gaming and something the medium does well by balancing difficulty and the user's skill level to not be boring while not giving anxiety [34]. Kiili [33] tried to make a bridge between game design and education and does this by making a model which builds upon Kolb's experiential learning model, Figure 2.6. He explains it as a beating heart, pumping challenges in which the learner has to generate solutions to overcome. This idea generation is done in the ideation loop and is most effective if done in groups. The users then test their solutions in the experience loop. The ideation loop is required to clean the experience loop of old solutions by feeding it with new and creative ideas [33].

2.3.4 Motivation in Education

Arguably, one of the most influential forces in learning a second language is motivation [7] [35]. Lightbown and Spada [36] presents findings that the learner's motivation and, more importantly, how the teacher tries to increase their motivation seems to impact the learner's learning outcome.

Godwin-Jones [37] explains that there has been an increase in educational games with the growth of games' popularity and the evolution of attitudes towards them. He claims

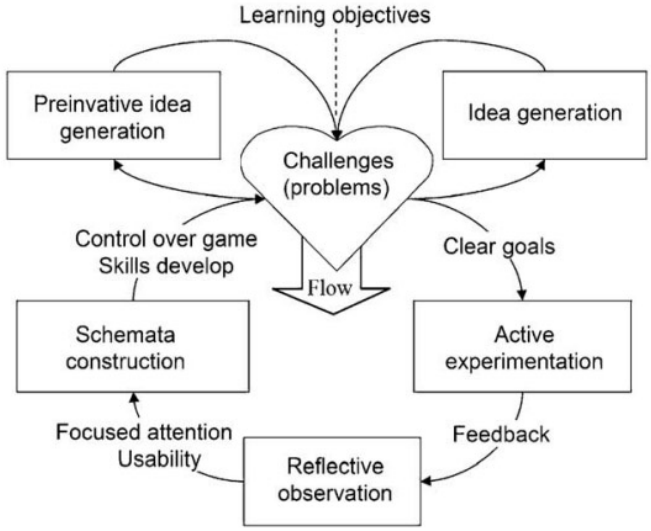


Figure 2.6: An illustration of Kiili's experiential gaming model [33].

this to be a good thing if done correctly, as people are in general motivated to play games and will in turn be either motivated to learn by playing or not even notice that they are learning at all. As explained by Kiili [33], games have the positive benefit of getting into the flow, increasing engagement and knowledge gained. On the other hand, if not careful, a game like this could also remove the focus on learning and have a negative effect on teaching [37].

Motivation is usually split into two categories: extrinsic motivation and intrinsic motivation. Deci and Ryan [38] defines intrinsic motivation as "[motivation where] there is no apparent reward except for the activity itself" while extrinsic motivation increases as the external reward increases. When talking about motivation in education, they state intrinsic motivation as being the most influential.

Godwin-Jones [37] then goes on to say that a goal of an educational game should be to give the player interest in further exploring the subjects presented in the game. In other words: increase their intrinsic motivation. Horwitz [35] supports this statement by claiming intrinsic motivation to be more important than extrinsic when it comes to language learning. But it is not all easy, according to Lightbown and Spada [36], as they explain that teachers have no real control over the student's intrinsic motivation and can only try to increase the extrinsic motivation and give them a feeling of success which might in turn increase their intrinsic motivation.

Bloom's Taxonomy, also called "taxonomy of learning", presents a hierarchy of learning in three learning domains: cognitive, affective and psychomotor [20]. The most relevant of these three is the affective domain, but is also the one examined least. It is demonstrated by these behaviours: attitudes, interest, attention, awareness, self perception and motivations. Measuring gains in this domain is found to be difficult, but motivation is being increasingly recognised as an important catalyst to learning and has been the focus

for measuring affective learning.

A concrete example is found in a study done on the impact of massively multiplayer online role playing games (MMORPGs) on languages where the players where communicating in a foreign language [39]. They found that participants playing, scored better on English language tests compared to the ones that did not play. They claim that the playfulness and fun aspect of the game motivates the participants to learn a secondary language. Their motivation was to better play the game, requiring them to communicate with other players. The extrinsic motivation of the game enhances the participant's intrinsic motivation for learning a new language.

However, it is found to be challenging to measure motivation as the variables are not directly observable [40]. Several methods trying to measure it has been developed, one of which being Bandura's self-efficacy scale [41], which measures the user's own belief in their ability to accomplish a task. It is described by Skaalvik and Skaalvik [42] to indirectly influence motivation as well as being important in their own right.

What factors affects motivation is still not clear, as Wehner, Gump, and Downey [7] says when researching Second Life (see Section 3.2.2): "the relationship between the introduction of Second Life and the perceived student motivation was clearer but the underlying causal mechanism is not definitive".

2.3.5 Summary of Pedagogy Methods

Given we don't have background or experience in pedagogy, but in informatics, we did not feel comfortable to completely base the design and findings on these pedagogical methods. But they are an important part of what we want to do, and must be respected in some kind of fashion. To compromise, we will use the theory on constuctivist methodology as inspiration when designing and developing the application. More specifically, social constructivism and Kiilii's experiential gaming model.

Chapter 3

Related Works

This section will present several related works that were made for language learning, both those that does not use VR and those who do.

3.1 Language Learning Tools

Heil et al. [43] reviewed the 50 most popular commercially available language learning applications for mobile phones. Evaluating them according to several criteria, such as: type of input and output, modes of grammar instruction, and type of corrective feedback. They found three major trends: "first, apps tend to teach vocabulary in isolated units rather than in relevant contexts; second, apps minimally adapt to suit the skill sets of individual learners; and third, apps rarely offer explanatory corrective feedback to learners." In addition, Heil et al. [43] found that even though there has been a pedagogical shift towards a more post-modern task-based instruction method [28], the apps were instructivist in nature.

But even considering this criticism, most of the applications available were helpful. An article by BBC reports that cultural diversity is increasing globally and that, at least in Europe, the younger generations know more languages than before. They point to the most important reason for this might be the quality and availability of educational apps [44]. This section will present two of the most popular language learning tools available today.

3.1.1 busuu

In 2008, Bernhard Niesner and Adrian Hilti founded busuu as a response to thinking language learning tools were missing an important social element. 11 years later, in January 2019, busuu had acclaimed more than 90 million users worldwide [45]. Some key features of busuu are interactive lessons with audio, translation and practice tasks. It has audio recordings of each vocabulary item and example sentences to place everything in context.

Additionally, users interact with other users by getting feedback on both written and oral tasks from native-speakers in the busuu community, as well as having an online chat platform to connect users as language partners [46]. Screenshots from the application running on different devices can be seen in Figure 3.1.

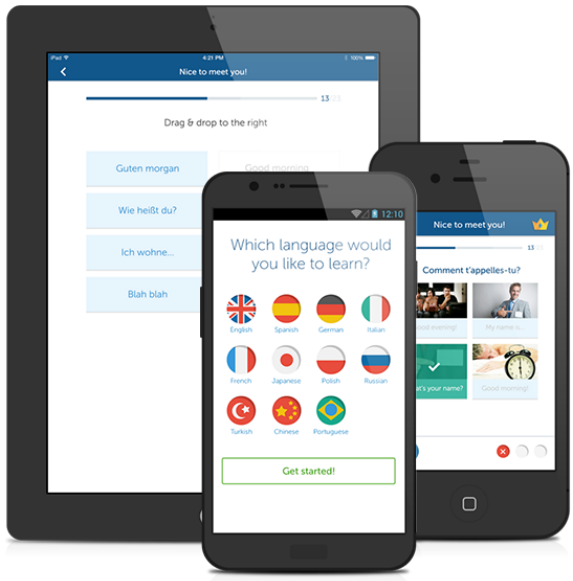


Figure 3.1: Screenshots from busuu on different devices.

Vesselinov and Grego [46] did a study in 2016 on the efficiency of language learning in busuu. They found that 84% of the users improved their language skills over the two month test period, where 42% of those improved by the equivalent of a full college semester or more of Spanish, with an average of 22.5 hours of using busuu to accomplish this. Every one of the participants who used the application for at least 16 hours made significant improvements on either their written test result, oral test result or both at the end of the study. Every participant who answered the exit survey also said they would continue to use busuu even after the study. But the effectiveness of the learning slowed substantially when moving to intermediate levels compared to the beginner levels which busuu is designed for.

In 2017, busuu teamed up with Oculus, owned by Facebook, to make a Virtual Reality application to teach Spanish. This application, "The Hacienda", is described in Section 3.6.

3.1.2 Duolingo

Duolingo is perhaps the most popular language learning application on the market [47] with 300 million users in 2018 (25 million of which were active users) [48]. It is designed as a game, where users complete tasks to gain currency in which they can buy character

customisations and bonus levels, as well as compare themselves to others on a leaderboard. These tasks include, but are not limited to, speaking phrases out loud and translating words and phrases both to and from the language to be learned. The tasks are made to be completed in short time and not feel repetitive but rather fun and addicting [49]. Screenshots from the application can be seen in Figure 3.2.

Figure 3.2: Three screenshots from the Duolingo mobile app showing the gamification of language learning.

After trying out the application for over a year in preparation for a trip to Italy and feeling confident in his Italian skills, Freedman, David H. [49] noticed a week before the trip that he could not even answer simple questions. He realised he had only learned the words and simple phrases in isolation, and could not use them in context in a natural conversation. This is a trend in mobile language learning applications according to a study done by Heil et al. [43], which concludes: ”apps tend to teach vocabulary in isolated units rather than in relevant context”. But Freedman found that it took only a short time of intense studying after the 70+ hours spent in Duolingo to get a good grasp on the language, as the vocabulary was already in place.

Following the trip to Italy, Freedman, David H. [49] asked the co-founder and CEO of Duolingo, Luis von Ahn, if his experiences of not really learning the language was common. Ahn responded that it was nothing unusual, and that the main focus of the tool was to keep the users wanting to come back and learn more, and not necessarily on learning effectively: “We prefer to be more on the addictive side than the fast-learning side [...] If someone drops out, their rate of learning is zero”.

3.2 Language Learning in VR

When most people hear VR they think entertainment or gaming, but new uses are still being found to this day. One of the most popular and successful uses has been in training such as military and healthcare as well as in education [50]. Virtual reality has both drawbacks and advantages compared to other forms of teaching. Compared to real-world

classroom teaching, VR loses the physical aspect as well as the many little details in the world. One could think that VR is only an improvement over (desktop) web classes, but as of now VR is not nearly as accessible as desktop applications. However, VR is still seen as a powerful tool for education. In addition, given the findings of other works from a post-modern language teaching standpoint, experiential learning (as explained in section 2.3.3) is well suited to be used in correlation to language teaching in VR.

Declarative memory stores explicit facts and events, like "the mitochondria is the powerhouse of the cell". While procedural memory stores implicit skills, like cycling. Fotheringham [51] explains that in the world of language learning the focus is more on the declarative memory and less on the procedural memory. He believes on the other hand that the procedural memory is as important, if not more important, than declarative when it comes to learning a new language. This further points at experiential learning as a good fit for language learning and VR.

One big aspect of teaching has been mostly ignored in VR language teaching applications. Of the applications existing today, almost none of them are including the teacher. They are either for peers working together or, more commonly, for self-studying. A negative consequence of this is the lack of knowledge concerning the teacher's role in a virtual environment [3].

There has already been made several applications and done studies on VR application to be used for teaching new languages. We present some of the relevant ones here.

3.2.1 Crystallize

Crystallize is a 3D desktop application for learning Japanese where the user is placed in typical Japanese environments and can interact with virtual agents in Japanese. The application in use can be seen in Figure 3.3. Cheng, Yang, and Andersen [52] adapted the application to be able to run it in VR on the Oculus Rift. They also included tracking of the HMD to see if the user is bowing at the appropriate places, as bowing is an important part of Japanese culture and Cheng et. al. argues that culture is an important part of language. The importance of culture can also be seen in Norway's introduction programme [1].

Figure 3.3: Screenshots from the full version of Crystallize, with some more features than the VR version.

They found that the VR application compared to the non-VR gave better presence and their users felt that they were better connected to the culture and the people there. Most of the users learned when to bow and how to act in the given environment, but the language learning was a bit weaker in the VR version. They thought this was the case, as the VR aspect took some of the focus away from the language learning. In addition, seeing as the bowing part was only present in the VR version there was more happening in that particular version. They could not conclude anything on the language learning aspect.

Cheng, Yang, and Andersen [52] said that the technology they used was lacking, both the users and themselves saw faults in the current system. Common feedback was that the users felt nauseated and that the controls were difficult to use without seeing the mouse and keyboard. Cheng et. al. specifically mentions that using the HTC Vive to get better quality images and motion controls would be something to look at further, mostly to include motion controls and postures to further improve teaching physical interaction.

3.2.2 Second life

One other example of VR in education is Second Life. It was a tool that garnered attention and that many saw had great potential. It was created by a Californian based firm called Linden Research, Inc. (also called Linden lab) and opened to public access in 2003 [20]. Second Life provides many useful and playful features such as: customisation of player avatars, support for chatting with other players (voice and text), adding multimedia objects (videos, images, recordings etc.) and ability to teleport to other spaces [53]. The application could transport people to historical places or let people do things that might be dangerous in the real world. Even today, many educational institutions have set up hubs in Second Life which users can visit. Screenshots from the application can be seen in Figure 3.4.

Stevens [53] believes the interest comes from a combination of a change in culture and advancement of technology in that time. A time where people gained more access to ubiquitous devices with more computational power. There were also many who began to change their opinion of digital worlds for teaching. Stevens explains Second Life is a playground where people could augment their interaction with each other through a constructivist approach. It promotes the idea that education can have a sense of experimentation and enjoyment. Something which builds upon activities people have in their daily lives instead of giving the feeling of being locked down within the walls of an institution. Molka-Danielsen and Deutschmann [20] adds to this saying that Second Life supports an empathic factor by enabling user's to step into others' shoes. Furthermore, one could use the same factors gaming industries use to increase motivation and emotional engagement in both characters and the artificial world.

Second Life in Language Learning

Wehner, Gump, and Downey [7] says that one of the most influential forces on a person's ability to learn a language is motivation. Which means that providing students with engaging and interesting experiences can lead to a more complete acquisition of their target language. The thought behind using Second Life is that it can introduce an arena across many languages and levels which holds a potential for a more communicative form of

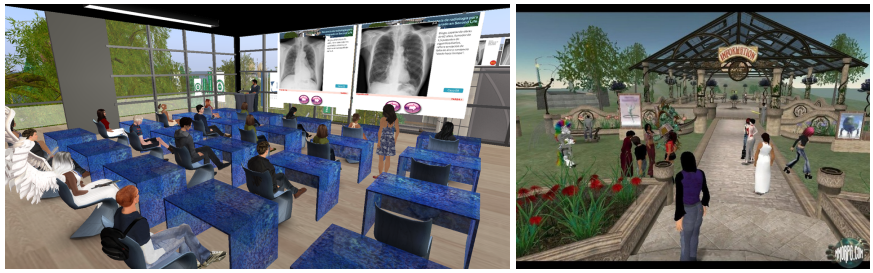


Figure 3.4: Screenshots from Second Life.

teaching and learning. By doing this, a level of social integration can be achieved which entice users to communicate and make an enjoyable learning environment. In addition, since the application is available to people all over the world, there is an opportunity for new and interesting relationships. Friendships made inside the virtual world can extend to real life, which can lead to a broadening of social and cultural attitudes. This is a way of learning based on the social constructivist theory explained in Section 2.3.2. Relevant to this case is one important assumption this theory makes: learning takes place when individuals participate in social activities.

Another reason Wehner, Gump, and Downey [7] mentions to be a supporting factor for Second Life, is the use of avatars as new identities. Mostly because there are those who want to keep their identity to themselves and may cause them to not fully integrate into a language community. This problem might be something that is not an issue for adult language students, but the new online identity can still be used for acquiring new knowledge of a language outside their standard social understanding.

Second Life was used to carry out different language teaching and learning projects in 2007 and 2008. The goal was to see how a group of educators could find models for using the environment in language teaching and also to map practical issues involved using Second Life in a realistic teaching context [20]. At the same time, they also wanted to conduct research on learner attitudes and performance in the environment. In the project, they made also made use of Marratech, a traditional online video conferencing tool, in combination with Second Life. This was then compared to a different Second Life environment. Afterwards they collected data through questionnaires and personal interviews.

The result of the experiment [20] was that many had individual preferences and therefore they could not find a definitive answer to their questions. Some felt that the use of avatars made them feel more safe and limited exposure, others could not take Second Life "seriously" and some also preferred the conference tool more since it provided more information such as gestures and facial expressions (better communication). Molka-Danielsen suggests taking learning perception into account when designing tasks in Second Life (this can be extended to other virtual environments as well) and education. Furthermore, they also noted that more research is needed to determine the extent to which different variables come into play in the environment.

Second Life does not have support for immersive VR systems and is classified as a desktop VR application. As we mention in Section 2.1.4, this can affect the feeling of place-presence and co-presence as players do not have a full experience of being in an

environment. However, with Second Life's focus on social hubs, social-presence would be supported. Actions that can be done in the application has lower affordance as one interacts through a mouse and keyboard. This mapping between the controls, actions and result is not as close to real life compared to what an immersive VR system can offer. The application also supports all the affordances that are related to communication.

3.2.3 Sansar

Sansar is created by the same company behind Second Life: Linden lab. It can be seen as an expansion of Second Life, and has similar features. With social hubs created by users where people can meet and talk to each other. The virtual avatars still has many customisation options to choose from, such as: clothes, body and facial features, accessories and hair. Screenshots from the application can be seen in Figure 3.5.

Figure 3.5: Screenshots from Sansar.

Since Sansar has the possibility to be used with Immersive VR systems, gives it a high level of immersion. This is positive for the feeling of place-presence and co-presence. Sansar also has the aspect of social hubs which maintains the social-presence that Second Life has. The use of controllers acting as virtual hands gives it also better affordance. The virtual hands communicate that actions from real life can be done in the virtual world, such as touching and grabbing objects. This is also a close mapping between actions, controls and results of an action. As we mention in Section 2.1.5, the application does not support reviewability or revisability, but compensates with the feeling of presence.

3.2.4 busuu: The Hacienda

"The Hacienda", created by busuu Limited, is an application that takes the user through a scenario with a story. The story revolves around a family preparing a party for someone, and you being there to help them. It is entirely focused on teaching Spanish which is done through speaking with the virtual agents. What the user says to them is interpreted by a voice recognition feature, and lets the story move on if pronounced correctly. There are different tasks involved, some examples are: counting, greeting other people and asking questions. Some of the words and phrases that you encounter are also added to an in-game dictionary where you can hear and practice on pronunciation. A screenshot from the application can be seen in Figure 3.6.

Figure 3.6: Screenshot from busuu: the Hacienda.

The application is mostly available on VR platforms that uses one simple controller, like the Samsung Gear VR and Oculus Go. With this simple controller, there is limited interaction that can be done; mainly moving around and clicking on objects and the User Interface (UI). Even though this still falls under the category of Immersive VR, the immersion itself is weakened by the limited interaction with the virtual world. This would again affect the feeling of place-presence and co-presence in relation to the virtual agents. The experience is also tailored for single-player and does not support collaboration. However, the introduction of the story and giving you the identity of a party guest could enhance the emotional investment that a user has in completing their tasks. The application also follows up on the recommendation from Molka-Danielsen and Deutschmann [20], by using the story and tasks that are similar to what can be found in the gaming industries.

This application is still in development, and different use cases for it has not been explored. During the time of writing this thesis, language teaching, for instance, has not been tested out, but all necessary tools for social interaction are in place.

3.2.5 VRChat

VRChat is a VR community with similar features to the ones found in Sansar. It has support for expressive and customisable virtual avatars, users can journey into worlds and different rooms, it supports both immersive and desktop VR, there is voice chat, and users can create their own content [54]. The avatar worlds, in this context, is an environment that players can enter; it could be a room, a game or anything that a user has designed it to be. Many of the worlds in VRChat is made by users, and there is a lot freedom in what can be created. The features that can be found is also not made with teaching purposes in mind. However, the freedom of control and creation might be useful for education nonetheless, but at the moment we have not found any findings to support this claim. There are also limitations on what worlds can be public and seen by others through means of verification. A form must be filled, sent in, reviewed in relation to their terms of service and then has to be verified. The virtual avatar in VRChat is also more customisable than in Sansar, as it can be created from the ground up. This means that one can make their avatar look like a

character from a game or even a cartoon figure as can be seen in Figure 3.7.

Figure 3.7: Screenshot from VRChat.

Because VRChat is quite similar to Sansar in terms of features, one will find the same qualities with immersion, presence, collaboration and affordances as well. The only real difference is the degree of freedom with representation in the from of the virtual avatar. In VRChat, there is greater flexibility since users can import their own custom avatars into the game. This strengthens the empathic factor through identity and more possibilities of seeing things form other perspectives as mentioned by Molka-Danielsen and Deutschmann [20] as well as by Wehner, Gump, and Downey [7].

3.2.6 Mondly VR

"Mondly: Learn Languages in VR" is created by ATi studios and is available on the VR HMDs with simple controllers like: Google Daydream, Samsung Gear VR and Oculus go [55]. It makes use of scenarios where the user is given options to choose what they are going to say in a conversation. For example, a scenario where you are speaking to a hotel receptionist and have to order a room in Spanish. To continue with the scenario, one has to correctly pronounce one of the options and it is interpreted with voice recognition. An example of such a task can be seen in Figure 3.8.

Mondly supports immersive VR in the sense that it uses a HMD, but the controllers are not as complex compared to the HTC Vive. It only has one controller that is meant for simple interactions, similar to "busuu: The Hacienda" mentioned in Section 3.2.4. The controller is also strictly not necessary, since interactions is mostly clicking buttons on the UI. This can be done by pointing your head towards a button and with a short delay the button is clicked. The affordance of this feature is aided by a signifier in the form of a dot in the middle of the screen. Because of the lack of virtual hands and no interaction with the environment and objects, this leads to a weaker feeling of immersion. There is also no collaboration as the experience is not meant for multiplayer.

Figure 3.8: Screenshot from Mondly.

3.2.7 Witly

Witly is a language tutoring application in VR [56], in which the users would pay a fixed price to receive a one hour lesson from a teacher. Users are represented by human-like avatars with no legs. The teacher had access to some tools, such as: the ability to draw in mid-air and changing environments. For communication, they make use of voice chat. A screenshot of the application can be seen in Figure 3.9.

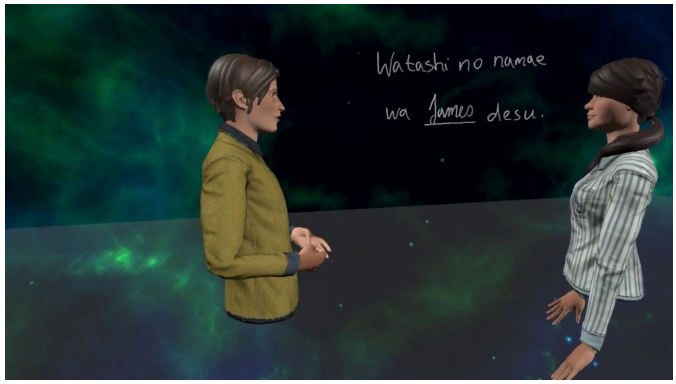


Figure 3.9: Screenshot from Witly.

At the moment, there is not much information that could be found about this application. This is because the company behind it, Edulus software, seems to have been shut down. As an application, Witly supports having a role for the teacher. Collaboration is also a part of the application, but seems to be limited to one teacher and one student. As many other of the VR applications, it mostly covers all affordances in regards to communication. However, other form of affordances is hard to evaluate properly as we have not experienced the whole application fully. When reviewing this application, there was only a demo that was available with no real teacher and had no form of interaction with the environment or any objects. The application also supports the use of HMD and controllers

which would hint towards high level of immersion. Though, this is hard to determine as it can be affected if there is limited interaction.

3.2.8 Pennsylvania State University VR Vocabulary Learning

Legault et al. [57] performed a study on Immersive VR that had the same focus and similar elements to the ones in our project. The focus of the the study was on second language acquisition where they tested Immersive VR environments for learning Mandarin Chinese words. This method of learning was compared to a word-word memorisation method, where one would see the Mandarin Chinese word and the corresponding English translation. They meant that language learning is associated with an embodied and perception-rich experience and that context is very important for learning. An argument they had was that first language acquisition is often more successful because second language acquisition is mostly done without context. Furthermore, those who study abroad show to improve second language fluency, enhanced communication skills and excel at second language vocabulary acquisition. Though it is worth mentioning that not all the studies they point to directly compared at "home learning" with studying abroad, and not all those who participated in those studies benefited equally from studying abroad.

The evaluation consisted of two sets of words: 30 zoo items and 30 kitchen items, and two different types of sessions: a VR session and a word-word pair association session. Participants were split into four groups of 16 people, each with different combinations of conditions and items, see Figure 3.10.

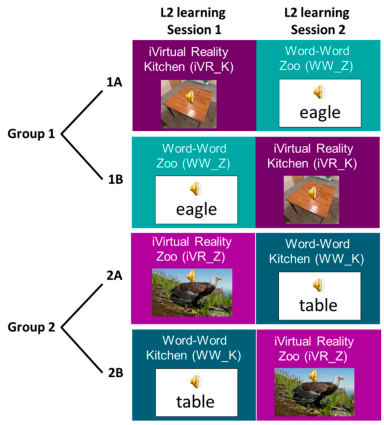


Figure 3.10: Group organisation in the Pennsylvania State University experiment.

In the end, the results show that there was a higher accuracy for words learned in the immersive VR method. It also showed clear benefits for those who were low-accuracy learners, while high-accuracy learners showed no difference. This result seems to point to immersive VR experiences as being great for novices, but the study also points out that it cannot be generalised for second language acquisition in general. They suspect that the factors which lead to effective second language learning may include high degree of

interaction and immersion. The objects in the kitchen were also more interactable than the ones in the zoo, because people were able to pick them up. They interpret this as one of the reasons why the kitchen objects were more accurately learned compared to objects in the zoo. This was further supported by the participants of the study who noted that the most effective element was that they could be engaged with the environment, and many of them said that interactable objects aided with this.

The equipment they made use of aimed for high immersion and, with the results in mind, it would seem that they achieved this. The kitchen environment also showed to have greater effect in immersion as it was more interactable. As before, this affects the feeling of place-presence. Though it would seem that there is no multiplayer involved meaning that there is no component for collaboration or co-presence.

3.2.9 A comparison of the VR applications

Table 3.1 compares every application mentioned in Chapter 3 on some of the main features wanted. An "X" means the application contains the given feature, while an "-" means the feature exists, but is limited. We will be explaining some of the features in Table 3.1 that might not be obvious.

The "Immersive VR" quality focuses on the support for immersive VR systems as we explain in Section 2.1.3. "Collaboration" is, in this case, support for multiplayer and social interaction, while "Norwegian" is if the Norwegian language is part of their learning content and "Teacher support" is if the application has their own teacher role. "Environment interaction" is specifically about the ability a user has to interact with objects in the environment.

Application	Immersive VR	Norwegian	Collaboration	Voice rec.	Teacher support	Several environments	Environment interaction
busuu			-	X			
Duolingo		X		X			
Crystallize	X		X			-	
Second Life		-	X		-	X	-
Sansar	X	-	X		-	X	X
The Hacienda	X			X			-
VRChat	X	-	X		-	X	X
Mondly VR	X	X		X		X	
Witly	X		-		X	X	
PSU Vocabulary Learning	X					X	X
Our application	X	X	X	X	X	X	X

Table 3.1: A comparison of both VR and language learning applications.

As can be seen from Table 3.1, no existing product had all features we wanted in a VR Norwegian teaching application. The most lacking feature was the support of Norwegian as most focus is on the most popular languages such as English and Spanish. And no other applications had both collaboration with other people and voice recognition.

Chapter 4

Problem Definition Process

This chapter discusses the process of how we created our problem definition. We mention why it was an issue, the methods we used to gather supporting data and end with a list of user needs and system requirements.

4.1 Issues with defining the problem

The task we began with was rather general: to find the effects of VR in language teaching. There were details to be defined, such as which language and who we would make it for. To begin the process, we got together with several language teachers in a seminar, which resulted in a choice of three languages: French, Spanish and Norwegian. In the end, we chose Norwegian since we were already familiar with the language.

Our motivation was clear, explained in section 1.2, but the actual problem to solve was not. As we delved deeper into the topic we had to make choices such as: what problems we would handle and which group we would focus on. It became clear for us that we would have immigrants as our user group. This was mainly because the language teachers we spoke with had immigrants as their students. The Norwegian language teachers were from NTNU and the adult education centre in Trondheim municipality, Trovo. With that said, we still needed a more specific user group since immigrants would be too general and broad. Luckily, there was a clear difference in the students taking the course giving us two options. NTNU had international students with at least secondary education background while the adult centre had immigrants and refugees with little or no education background.

We chose to go with the former as our workplace was located in a VR lab at NTNU Dragvoll; the same location where the teachers were working. This meant that keeping in touch with them and setting up meetings would be simpler. We also hoped to eventually have their students test our application and having them readily available next to us would ease this process. At the same time, as we were reading studies about immigrants and the introduction programme mentioned in Section 1.2, we found that there was little research being done on our user group. A directorate under the Ministry of Education called Vox,

who changed their name to “Kompetanse Norge” in 2017, received an assignment to map the offer of Norwegian language course with immigrants who had higher education. In their report they mention that the area had little information from before which made their work difficult [58]. Now that we had our user group there was still a need to learn about the situation of how language teaching is done today with that user group. To do so, we did observations and invited stakeholders to the VR lab where they answered a questionnaire.

4.2 Observations

At that time, we did not know much of how Norwegian language teaching was done. To find out more about this we made contact with Trondheim municipality adult education and Norwegian classes for foreign students at NTNU and asked if we could observe their classes.

We first visited the adult education where the class was a society study with extra focus on Norwegian and new foreign words. It was a small classroom with around 15 students, all with generally low educational background, sitting at desks in a half-circle. We noticed the teacher only spoke Norwegian, and had a focus on being understood and making sure that everyone was following his explanations. There was also a lot of time spent on interaction and conversation between the students and teacher. Later, the students got assignments that included tasks such as translating new words to their mother tongue and explaining concepts with each other. As the teacher explained afterwards when we spoke with him: the focus was on understanding and being understood, in contrast to being ”correct”. This methodology is similar to the postmodern language methods where the focus is on understanding [29].

At NTNU, the setting was similar with a similar amount of people sitting in the same orientation. But as the classroom itself was bigger, there was more gaps between students, giving them more space. The students also received small exercises during the lecture to be done orally and written. One obvious difference was that the NTNU teachers has a greater weight on grammar, vocabulary and sentence structure. They also had a faster pace when it comes to the explanations and when going through the curriculum. Furthermore, they have a greater focus on writing skills than their oral skills, and use English if someone cannot understand the Norwegian being used. As part of their curriculum they also receive mandatory assignments such as writing an essay about their day in Norwegian. In addition to the sessions in the classroom, some time were used at the “language lab”. Here, they listened to spoken Norwegian and practised their pronunciation, much like the audio-lingualism method described in Section 2.3.1.

Seeing how different these two settings were, we felt the need to choose one of them to be our target group. As the accessibility of students were better, we chose the latter: immigrants with higher educational background. Even though we excluded immigrants with little to none education, it might still be useful for everyone trying to learn Norwegian.

In addition to these Norwegian classes, we visited a Language café at the Trondheim library. Here, Norwegian volunteers and immigrants met up each week where they could come and talk in groups. The idea was to have a safe space to practice speaking Norwegian. Participants were divided into groups of five-six immigrants and one Norwegian

volunteer each, and received a sheet of talking points to discuss. We observed that these talking points were mostly used to spark a conversation. Discussions with teachers and students also confirmed that "having a theme to talk about is helpful when trying to have a conversation".

4.3 Questionnaire

To get more insight into the challenges when learning a new language we wanted to talk directly to the students and teachers learning and teaching Norwegian. Therefore, we made a questionnaire with the main purpose of asking what they thought the biggest challenges were. The complete questionnaire can be seen in appendix A.3.

14 students and eight language professors answered, all with different, non-Norwegian, background. The students were all in the same Norwegian class and had been learning Norwegian for two-three months, and the professors had experience ranging from five to 20 years.

The results told us that there was a general consensus on the fact that pronunciation, vocabulary and grammar was difficult. What was maybe less obvious was that many found the lack of authentic interaction and having someone to talk to as one of the biggest challenges.

We kept the students' and professors' answers separate, as we thought it might me interesting to see if there were any discrepancies between the teacher and student on what was challenging. The results can be seen in Table 4.1 and Table 4.2. Overall, there was actually little difference, except e.g. the small changes of ranking challenges: students had pronunciation as a clear biggest challenge, while the professors had it as the third biggest challenge. Many students also brought up that lack of time was a big hindrance. This was barely mentioned by the professors.

Challenge	# of responses
Interaction and authenticity	4
Vocabulary	4
Pronounciation	3
Grammar	2
Practice	2

Table 4.1: Coded result from language professors asked what they think students find challenging in language learning. Answers only mentioned once are omitted.

The questionnaire also asked if they had more belief in a system with other people or a system using Artificial Intelligence (AI) and voice recognition. There was an agreement that talking to another person was preferred, 13 in total against five for AI (four not comfortable with their own expertise answering the question). It should be mentioned that several mentioned that they had little experience and was unsure if what they answered was what they actually felt in practice.

Challenge	# of responses
Pronunciation	8
Vocabulary	5
Grammar	5
Not having someone to talk to	3
Lack of Time	4
Speaking	3
Listening	2

Table 4.2: Coded result from students asked what they find challenging in language learning. Answers only mentioned once are omitted.

Analysing the results from the questionnaire we wanted to focus on speaking to enhance pronunciation, vocabulary and speaking in general. It also seemed like speaking to other people was preferred, so having multiplayer functionality was key. This was the final action done to understand the domain and define our problem, and gave us enough to do so.

4.4 Defining System Requirements

Towards the end of this whole process, things became more clear to us as to what problem we could focus on and who it was for. The user group was something we decided early on in this period, but the problem took longer time. We had to gain an insight into our stakeholders and in what area improvement could be done. In the end, there were certain things we made note of. The first was the classroom and how teaching was done there. It was a traditional setting where students would follow a lecturer and maybe at times receive small oral and written assignments. It had a rather strict structure that followed a certain plan with a lot of the time occupied by the teacher going through many examples and explanations. The focus was to teach them the basics of grammar, sentence structure, definitions and increase their vocabulary. However, this brings up an issue that was backed up by both the teachers and what we witnessed which was using the language in practice. Students received much of the theory in the classroom, but outside of the classroom the Norwegian language was not being used. Many would switch over to English or their mother tongue instead. This would be again reflected in the data we gathered from the questionnaires. Therefore we wanted to focus on this and wanted to find something that would motivate conversations and the use of the Norwegian language. This idea is further explained in Chapter 5.

To get a better overview of the requirements of the application we listed up the most important user needs and then requirements answering them. The following subsections explains them.

4.4.1 User Needs

When figuring out the needs of the users we looked at both previous studies and collected our own empirical data, as mentioned in Section 4.2 and Section 4.3. To more clearly separate the origin of the needs, they are presented in two separate tables: Table 4.3 and Table 4.4; with the exception of UN1, which was present in both sources. User need 1, or **UN1**, was the need mentioned the most, by far, by both studies and the students and teachers we spoke to. This is because motivation is seen as one of the most influential forces in language learning [7] [28] [58].

ID	User need
UN1	Motivation to learn
UNT1	Use of technology in education
UNT2	Collaboration
UNT3	Social constructivism and experiential learning
UNT4	Teacher's role

Table 4.3: User needs derived from theory.

The four most important user needs found in other studies, see Chapter 2 and Chapter 3, are presented in Table 4.3.

UNT1 comes from the fact that there has been a culture shift, where people are getting more and more used to technology and as a result the use of technology has been realised in several aspects of our lives, one of them being education [33] [59]. Other reasons for the need of Virtual Reality in education is the growing accessibility of both VR hardware and software [12], and studies showing that there is less stress involved doing assignments in a virtual environment [4].

UNT2 is derived from from language being a social science and a huge opportunity for technology is giving access to meeting people with different background, culture, expertise levels and experiences [7].

There has been a shift in pedagogy the last decades from instructivist methods to constructivist methods [32], these theories and methods is accumulated in **UNT3** and further elaborated in Section 2.3.

UNT4 is derived from the lack of focus on the role of the teacher in related work. Lin and Lan [3] also mentioned this as a gap in the knowledge and that people should start studying solutions.

ID	User need
UN1	Motivation to learn
UND1	Norwegian not spoken outside classroom
UND2	Pronunciation
UND3	Vocabulary

Table 4.4: User needs derived from empirical data.

From the initial observations, interviews and questionnaires we did, we contrived three additional user needs (as well as UN1, which was mentioned in Section 2.3.4) which can

be seen in Table 4.4.

Variations of **UND1** (user need data 1) was mentioned several times by both students and teachers. One important aspect of obtaining a new language is practising [32]. Not having a platform, motivation or bravery of speaking Norwegian with native Norwegians is highly limiting. The few platforms that exists, see Section 3.1, are lacking authenticity according to the students and teachers.

UND2 and **UND3** is usually mentioned together as the two factors that are the most difficult when learning Norwegian. Although important, they will not be the main focus in our application, but some consideration will be done of improving both.

4.4.2 Requirements

Considering the user needs, we came up with a list of requirements that the application should fulfil. Each requirement is a result from one or more user needs addressed and are all listed in Table 4.5. Which particular need each requirement tries to answer can be seen in Table 4.6. Functional and non-functional requirements are not separated and Table 4.5 consists of both types, this was done because many of the requirements are both functional and non-functional.

ID	Requirement
R1	The application should be usable in a classroom setting.
R2	The application should support at least 8 people simultaneously over long distances.
R3	The application should increase motivation for users learning Norwegian by having interaction with the virtual environment.
R4	The application should have an avatar representing the user which anonymise the user to conform to social integration.
R5	The application should increase relatedness by letting users interact and communicate with each other.
R6	The application should increase the user's sense of mastery by giving points when performing well.
R7	The application should have a feedback system on the user's pronunciation.
R8	The application should support the making and solving of task-based instructions.
R9	The teacher should have additional tools to help them customise the students' experiences and give variety to the sessions.
R10	The application should be easy to use for both teachers and students.
R11	The virtual environment should be authentic and enhance immersion.
R12	The user should be able to access new words encountered and be able to re-read and hear them.

Table 4.5: Requirements for the application trying to answer the user needs found.

The idea, which is described in more detail in section 5.3.1, was to have a virtual Norwegian forest where several students could talk to each other in Norwegian. The forest would contain interactable objects which the students could read the Norwegian word of,

hear the pronunciation of and try to say themselves. The teacher has additional tools to be able to customise and facilitate the sessions in the application, and be better able to observe the students.

User need	**Requirement**
UN1 motivation	R3 Environment interaction
	R4 Anonymous avatar
	R5 Between-user interaction
	R6 Points
	R7 Pronunciation feedback
	R9 Teacher tools
	R10 User friendly
	R11 Authentic environment
UNT1 use in education	R1 Use in classroom
	R2 8 person support
	R8 Task-based instructions
	R9 Teacher tools
UNT2 collaboration	R2 8 person support
	R4 Anonymous avatar
	R5 Between-user interaction
UNT3 experiential learning	R3 Environment interaction
	R5 Between-user interaction
	R8 Task-based instructions
	R9 Teacher tools
	R11 Authentic environment
UNT4 teacher's role	R1 Use in classroom
	R6 Points
	R9 Teacher tools
	R10 User friendly
UND1 Norwegian not spoken	R3 Environment interaction
	R4 Anonymous avatar
	R5 Between-user interaction
	R7 Pronunciation feedback
	R10 User friendly
UND2 pronunciation	R6 Points
	R7 Pronunciation feedback
UND3 vocabulary	R12 Revise words

Table 4.6: Connection between user needs and requirements.

Chapter 5

Development

This chapter will present the development environment and describes the development process done. The most important features will be explained in detail, and the biggest challenges will also be discussed.

5.1 Development Environment

For the development of our application we chose to use the agile framework: Scrum [10]. The framework would cover the development step of the design and creation method [8]. We also had previous experience with Scrum from past projects, and were comfortable with the Scrum routines. At the same time, we only wanted to use certain elements that we saw as useful for this project. Table 5.1 summarises the elements that we took from Scrum and incorporated into our development process. To visualise the workflow, we used Github and the browser extension Zenhub. For sharing documents, such as interview guides and sprint backlogs, we made use of Google Drive.

There exists several development platforms for making a VR multiplayer application. A list of some that were considered can be seen in Table 5.2, as well as pros and cons in regards to what we wanted from a platform. In summary, we were looking for a stable and customisable platform supporting immersive VR. Of these options, we chose to go with Unity as it was the best fit.

Second Life is a tool that has been used before for educational purposes and had many of the fundamental functionality. Despite this, it does not support immersive VR meaning that it did not fulfil one of our main requirements for a development platform. Sansar can be seen as an extension to Second Life, introducing immersive VR, but it is still in early beta. This means there might have been a risk of being less flexible and having little support. VRChat was also very promising with the same features that Sansar had to offer and a large community. Nonetheless, it seemed quite limiting for custom development in terms of the virtual environment because of their verification process. The application also

Scrum element	Description
Daily meetings	15 minute meeting where three questions are asked for each team member: what have you done since the last daily meeting? What will you do now and the next daily meeting regarding the project? Is there anything that is impeding your work and do you need help? This was a good way of staying updated to what had been done since last time.
Scrum board	A simple board that kept track of our tasks. The board was divided so that one could keep track of which tasks was in the backlog, that has been started, being reviewed and what has been done. It showed an overview of what we would be doing in a sprint and how much time it would take overall.
Sprint planning	A simplified version where we planned our sprints, this meant setting priorities and estimation to our user stories. Afterwards, we had to decide which user stories would be included in the sprint and divide it into smaller tasks.
Retrospective	A meeting where we discuss how the project is progressing and what we can do to make it more effective or hinder impeding it for the next sprint.

Table 5.1: Description of the scrum elements used in our development

required all users to sign up which would go against requirement R8: usable in a classroom setting.

Unreal Engine and Unity are both robust game engines used in the industry today. These two game engines grant a lot of freedom for customisation as they are solely focused on being a development platform. While the others mentioned are primarily a social platform with some support for users to create content. With these game engines, the possibilities for what can be created is basically endless and documentation is easily accessed on their websites. We also have experience with both platforms and felt that Unity has a lot more activity on forums, in regards to asking and answering questions, than Unreal.

To clarify, one of the setbacks we saw from the Unreal Engine platform is based on personal preferences from our experiences in previous projects, while also wanting to learn more of Unity. We were therefore more inclined to choose Unity as our development platform. We started developing on Unity version 2018.2.13 and updated as newer versions were released. Some of these updates fixed errors in our application and we wanted to make it easier to further develop the application after we were done with it. The finished application used Unity version 2018.3.11.

Platform	Pros	Cons
Second Life	Made for making social worlds and has support for users creating their own content.	No support for immersive VR.
Sansar	Can be seen as an extension of Second Life, but updated and supports immersive VR systems.	Still in a beta version and not much community support.
VRChat	Has similar features that Sansar and Second Life offers (voice chat, multiplayer and customisable avatars). Players have freedom to create own content through Unity	Content that is created by users must be verified. Custom scripts are not supported. Users must sign in through VRChat's services.
Unreal Engine	Robust game engine used a lot in the industry, documentation is available online and has great flexibility for development.	Little support from development community.
Unity	Has an active and large community. Documentation is also available online and grants great flexibility for development.	Not much done in multiplayer VR. A lot must be done from scratch.

Table 5.2: A list of development platforms with pros and cons for use in a project similar to ours

5.2 Design Process

We followed the guidelines of user-centred design [11] when developing. In this particular project, this meant including both teachers and students, the end-users. During development, we asked them for feedback and comments on how to proceed with development, and changes to be done to the design. This was done to closer work with the end-user and create something that they more likely would want, but at the same time let us work with experts in the field and get feedback on the pedagogical aspect of the application.

As mentioned in Section 2.3.5, we have little experience in pedagogy, but wanted to respect the theory and methods found to be useful. We therefore had social-constructivism [20] and Kiili's experiential gaming model [33] in mind on the initial design as well as whenever we would make changes to the design. The most important part here was to adhere to constructivist methodology's most important thoughts, i.e being process/action-oriented and being more interactive, see Section 2.3.1. To better adhere to these concepts, we continuously discussed the design and development with the teachers.

5.3 Application Concept

Taking inspiration from the existing applications described in Chapter 3, several design choices were made to conceptualise our application. Social presence and collaboration were the most important aspects of our application. We took inspiration from applications like Sansar and VRChat, where people were represented by virtual avatars and can communicate freely with each other using spatial audio. Sansar, VRChat and Witly also makes use of immersive VR with both hands and head being tracked, this increases immersion and affordance. By developing with the HTC Vive, we would get the same level of immersion and some of the same affordances. The environment was chosen to be a forest because we wanted to capture a relaxing atmosphere for storytelling and also to create a "typical Norwegian setting". Because, as mentioned before, the Norwegian introduction programme introduces immigrants to both the Norwegian language and Norwegian culture [1].

The concept of our application changed throughout the project, mostly because of the agile workflow and user-centred design.

5.3.1 Initial Idea

Our initial plan was to create more of a game that had a focus on telling a story, inspired by the card game called "Once upon a time" [60]. The idea was to have an environment that was similar to the "Forest" environment we ended up with and players would gather around the campfire to tell stories to each other. This was going to be done through cards that had a word on it and a depiction of that word. The words could be anything and a player would need to tell a story around these words. Voice recognition could then be used to listen in on the storyteller and when the word is spoken then the card would disappear from their hand. After the card disappears from the hand then the object would appear above the campfire and maybe an animation would play out. We thought a game would improve motivation, as explained in Section 2.3.4, while also influenced by constructivism, more leaning to the cognitive-constructivism than social-constructivism as explained in Section 2.3.2. This application could be used as a supplement in, or even replace, the language lab used at NTNU observed in Section 4.2.

This was only a vague idea for the application and we presented it to some of our users for feedback, mainly teachers. The teachers were positive about the idea, but at the same time had little experience with VR so they were not certain how it would work out in the end. To get feedback from a more experienced perspective in that domain, we also included our supervisor. Through a conversation with her, it became more apparent that the idea had several weaknesses. Interaction was limited in many ways. By placing them around a campfire to tell stories, it would constrain the freedom of movement that VR and the hardware grants. This also meant that the environment could not be fully explored and would only remain in the background. Objects was also limited as players only had cards that they could touch and use.

As an effort to introduce a more dynamic experience, we changed it so that the players did not have cards. Rather, the game would have two phases. In the first phase, they would go around the environment and by interacting with objects in the world they would collect words in an in-game dictionary. Afterwards, they would gather around the campfire and

tell stories with the words that they had gathered. This also better reflected Kiili's experiential gaming model [33], Section 2.3.3, and shifted to better suit the social-constructivist methodology. This was the idea we had started out with, but it again changed drastically under development because of feedback and technical issues. What kind of feedback we received and the technical issues will be explained in 5.4 and following subsections.

5.3.2 Final Version

A lot changed between the finished work and the initial idea, mostly because the users were involved during the whole process and would often bring up great suggestions and variations. This user-oriented design process gave us more and more insight in the challenges foreign students face when learning Norwegian and gave us the ability to make a better suited application.

The finished version dropped the game aspect of playing cards to tell a story and instead was more of a tool for teachers to use in classes. The environment was the same, but the cards were replaced with the objects in the world the users could interact with. The teachers were given tools to work with, such as invisibility, the ability to create, delete and edit objects, and the ability to save and load worlds. The users were given more freedom to move around the environment and play with the world to better use the things VR gives.

The rest of this chapter describes development towards the final version. Especially Section 5.5, which thoroughly describes the most important features found in the application.

5.4 Sprints

With the Scrum method, we worked in sprints. Each sprint was three to four weeks long with a total of six sprints, where the final week of each sprint was used to test new features with our user group: Norwegian teachers, international students and minority students. Earlier sprints take on features that are either necessary foundation for features in later sprints or had higher priority. An example would be that we worked with voice chat before starting on voice recognition. Table 5.3 lists the main features developed each sprint.

Sprint	Features
Sprint 1	The VR environment, player avatar, multiplayer
Sprint 2	Voice chat, interaction with objects in the environment
Sprint 3	Voice recognition, object assets, in-game dictionary and lobby
Sprint 4	Teacher-mode, avatar customisation
Sprint 5	New environment and tutorial
Sprint 6	Voice recognition, improved UI, Oculus support, save/load functionality and ability to edit objects

Table 5.3: A summary of all our sprints and the features developed.

It should be noted that some of the features that were started in one sprint carried on to a later sprint. This might be because it being more difficult than anticipated, or issues regarding the feature emerged in a different sprint. An example is voice chat: it seemed to work properly in Sprint 2, but suddenly players were not able to hear each other when used again in Sprint 3. There were also several lesser features developed not mentioned in Table 5.3, a more thorough feature list can be seen in Appendix A.2.

5.4.1 User Testing

As mentioned, at the end of each sprint we invited teachers and students over to participate in user tests. We also got into contact with a local high school in Trondheim, Lukas vgs, who had access to several minority students we could perform tests with as well as language teachers interested in our work. All the teachers had experience with teaching Norwegian or other languages. Two of these teachers met with us regularly each sprint and followed the project from beginning to end. While There were four other teachers who only attended once or twice, two from Lukas vgs and two employees at NTNU. This feedback from teachers was especially beneficial as we did not have experience in language teaching and had less knowledge about the pedagogical theory and how it could be used in practice.

In addition to testing with teachers each week, we had somewhere between two and ten students testing the application. There were two significant groups of students participating. The first group were students who were exchange students and attending university. They were recruited through different school organisations such as: International Student Festival in Trondheim (ISFiT), Erasmus Student Network Trondheim, International Students' Union and participants at the Norwegian language courses at NTNU. While the second group were high school students from Lukas vgs who were immigrants, but had at least secondary education. An important distinction between the two groups were that the second group were minority students who had little experience with technology in general. Because of this they had more difficulties with using the hardware. Both these groups were attending Norwegian courses.

Each test consisted of the users being in the virtual environment with each other or one of us if they were alone and trying out small exercises showcasing the new features. After the test, we performed a semi-structured interview where we would ask them about their experience. We also made note of the user's background, such as their expectations and if they had tried out VR before the test. The test guide for the second sprint can be seen in Appendix A.4, other test guides look similar.

When planning the following sprints, we heavily relied on the feedback given during each test. This is described in the following sections. Having a mix of new users and reoccurring ones meant that we got both new ideas and a better understanding of the existing plans. Following this method of user-centred design [11] helped us create something better suited for both the teacher and student.

5.4.2 Sprint 1

The features we worked on this sprint were the highest prioritised user stories, seeing as they were the basic features which everything else depended on. By having these, we could receive feedback on atmosphere and give a general idea of interaction in VR and what the application could look like. One of these features was the virtual environment. We explain our thoughts behind the design of the environment in Section 5.3. The environment also had placeholder objects, in the form of low-poly apples, that could be picked up and thrown. A user was represented by an avatar that consisted of a torso, a mannequin head and hands, it had no legs, arms or neck. A screenshot showing these initial features can be seen in Figure 5.1.

Figure 5.1: Screenshot of initial avatar in the forest with the placeholder objects.

During the user tests, we wanted to hear what the users' first impressions were. As this was still at an early stage so we were open for changes and feedback for potential features. By giving them this basic environment, we had hoped to give them some context as they already knew about our main idea. Overall, many were positive about the experience. They saw this as an opportunity to create learning more "fun". All the testers liked the atmosphere and look of the environment. They felt it was authentic, "Norwegian", "cozy" and relaxing. However, they also felt it was quite empty and wanted more objects to play with. This was an expected reaction as we had not created any specific activity yet. As for interacting with objects, people felt that grabbing and picking up objects were entertaining and worked smoothly, but they also wanted the objects to interact with each other and to be able to see when other people picked up objects as this was not currently working. The testers also wanted to customise their avatar and make it more personal. Additionally,

even though they learned the controls quickly, they expressed worry for people who might experience difficulties and suggested to add a tutorial. They also had concerns about different forms of communication such as: body language, facial features and worries about how one would know who was talking. As for the storytelling activity, as we also learned through our observations detailed in Section 4.2, they wanted a theme on what they were going to talk about. A few also mentioned that the teacher's presence should be known.

The last concern about the teacher was interesting for us since the application at that moment was completely independent from the teacher. We wanted to use voice recognition as a passive way of keeping of track that people spoke Norwegian and give them points accordingly. This was a challenge for us because we were still uncertain how to involve the teacher outside of being only an observer or outside assistance. The feedback from this first user-test helped clarify and shape the rest of the project, for both us and the users helping us along the way.

5.4.3 Sprint 2

The first sprint only had object interaction for a single player, the actions were never synchronised between the players. This meant that if one were to pick up an object in the world, others would not see the object being moved around. In addition, since basic multiplayer was in place, this meant we now needed to fix communication between players other than hand motions, which meant implementing voice chat.

This sprint had fewer testers that could show up and we were only able to receive feedback from two people. The testers had some VR experience, but had not tried the HTC Vive before. They commented about how the environment broke the rigid structure of a typical classroom and that they wanted to be there more often. The voice chat worked as intended and no specific comments were made about it. The objects also appeared to be in sync between users, but there were still synchronisation issues to be fixed as explained in Section 5.6.1. We also asked about the concept for the application in the context of their experience. There were three things that they mentioned: they wanted more objects that were connected to the environment and Norwegian culture, a more practical setting for the environment and keeping the student's language proficiency in mind.

During this time, we still had placeholder objects, but it became more apparent what kind of objects people wanted. Objects that were related to the environment seemed obvious, but objects that were seen as "Norwegian" was also important. It was also suggested to have a more practical setting for the environment that was part of a student's daily life, such as: a café or a pub. They felt this way because it would answer their biggest need: a way to practise the language in specific situations related to their daily life. The student's language proficiency is about how much knowledge and skill a student has with a language already. The testers wanted us to keep in mind that people with different levels can also affect learning, in matters of difficulty with a task and how they interacted with each other.

5.4.4 Sprint 3

We continued with our work on what type of objects would be in the environment. Our feedback from sprint 2 gave us a starting point. The goal was to add objects perceived

as part of the Norwegian culture given the context. In this case, we had to have objects that were related to the forest, typical objects that are brought to camping trips, while also following the guidelines of lexical sets which was recommended by the language teachers [61]. The guidelines says that one should avoid having confusingly similar words. An example of this having a negative effect would be: fast and rapid, while a positive example would be: apple and orange. These objects ended up being: a tent, an axe, a stone, flowers, apples, oranges, a lunchbox, a backpack, a forest knife, a camera, a flashlight and a sleeping bag. The objects also had their names visible when picked up, and an audio clip of the pronunciation of the word. At the same time, we began to look at voice recognition; this process and the challenges related to it are described in Section 5.6.3. Finally, we also added a lobby where the users could log in with their own name, which appears over their head, create a room and connect to a particular group, a screenshot of the nametag can be seen in Figure 5.2.

Figure 5.2: Screenshot of another user with nametag over their avatar's head.

When testing, the feedback on the new features were positive and everyone meant we were working in the right direction. There were some confusion with the lobby and they wanted even more interactable objects in the world and interaction between them. It was during this time we began to experience difficulties with voice recognition, detailed in Section 5.6.3. Which made us question how to implement feedback and at the same time keep it pedagogically relevant. At the same time, we still had questions about a teacher's role in the application and the findings from Lin and Lan [3] which pointed out the lack of studies on the role of the teacher in VR. This would be the time where we would pivot and drastically changed the goal of the application from an educational game to a teaching tool for the teacher. The change would include ideas for a teacher mode and giving them additional tools. As a consequence of this, user need UNT4 was added which was "Teacher's role", the full list of user needs can be seen in Section 4.4.1. This in turn also produced new requirements that focused on the teacher's tools, R8 and R9. And R6 was removed because of the difficulties with voice recognition. Lastly, the requirement about giving feedback to user's on pronunciation (R7) was no longer the application's responsibility, but instead given to the teacher. The full list of requirements can be seen in Section 4.4.2.

5.4.5 Sprint 4

After the previous test, we acted on our decision to include a teacher mode. This was a type of user which could be accessed through the menu by entering the game with a password, screenshots of the lobby can be seen in Figure 5.3. With this, the user would have access to several tools, such as: turning invisible, having all implemented objects in their dictionary and being able to add them at will and delete already existing objects. Another feature added was giving the user a way to customise their avatar. We did not have much time to work on this and we did not have access to many 3D models either. Because of this, we decided to keep it very simple by allowing users to choose their own colour.

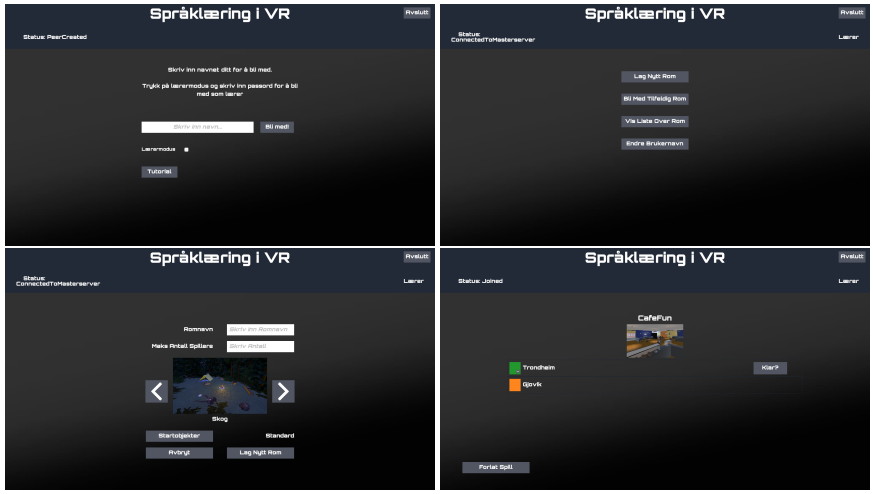


Figure 5.3: Screenshots of the lobby used to create and join virtual rooms. It is also here users write in their name and if they are a teacher or student.

The new tools translated to more buttons in the menu for the teacher. This added complexity to the teacher-mode made navigating the in-game menu difficult, and needed to be improved. The in-game teacher menu can be seen in Figure 5.4, along side of the student menu.

Figure 5.4: Screenshot of the in-game menu for teachers (left) and students (right).

When testing, the worry that was expressed early on began to resurface as well, being the lack of a tutorial. This was an issue that we had made note of, but was delayed because

most of our testers learned pretty quickly and having lower priority than other features. However, our testers this time were from Lukas vgs, more detail of the tests is in Section 5.4.1. They had difficulties navigating with the buttons on the controllers and were not used to the VR technology at all.

One feature we thought would be nice to have was recording of the classes, audio or video. Even though the teachers agreed that this would be nice in theory, they have similar functionality today and never bother to use it in practice.

5.4.6 Sprint 5

During this time, all of the important features were implemented and we could now focus on a second environment. This environment was chosen to be a café because of the feedback from an earlier sprint, mentioned in Section 5.4.3, and shown in Figure 5.5. Additionally, we created separate tutorials for both the teachers and students. The tutorial went through using the buttons on the controllers and how to navigate the in-game menu.

Figure 5.5: Screenshots of the urban café environment.

We did not test this sprint, as we were nearing the end of our development period. Instead, we chose to fix all known issues at that time and prepare the application for the final evaluation. Other than the tutorial, there was also no new functionality added. There were some who tried out the tutorial briefly, but they were not in our user group. In hindsight, we should have tested the tutorial more properly as it was later found to be lacking.

5.4.7 Sprint 6

Up until this point we had developed for the HTC Vive, but half of the final evaluation was to be done at Lukas VGS, where they only had the Oculus Rift. This meant we needed to make the application able to run on both HTC Vive and Oculus Rift. Also, unexpectedly, Unity now reached back to us with a solution to the voice recognition problem, see Section 5.6.3. At this short notice we did not have time to create a proper feature as we intended for voice recognition, but we wanted to do something to give the users an idea of what is possible with the technology. This was also a way of implementing requirement R7, giving feedback on pronunciation, in a simple manner.

Given the previous feedback, we wanted to improve the UI. In an attempt to do this, we changed some of the iconography as some users mentioned it would be more intuitive, the updated UI can be seen in Figure 5.6. We also added helping text to the user's hand when hovering over a button, this can also be seen in Figure 5.4 where the text over the user's hand describe the button's functionality. Finally, to complete the teacher-mode, we added the ability to save and load the world as well as edit the colour and size attributes of interactable objects. This was all done via the in-game menu, making it even more complex.

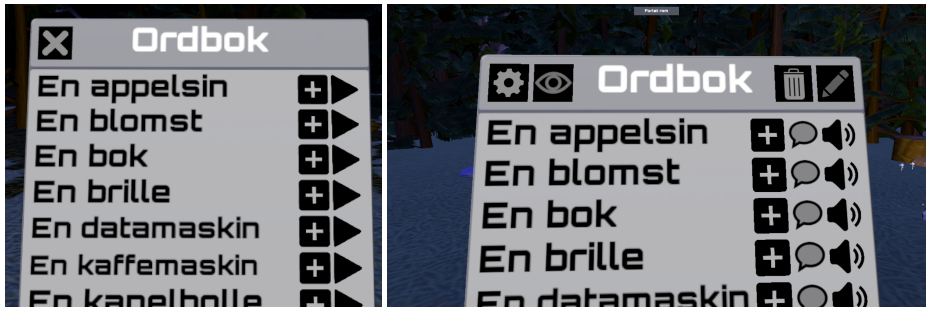


Figure 5.6: Screenshot of the in game menu before updating the iconography(left) and after (right).

There was also no tests directly related to this sprint, as the final evaluation was to be run afterwards. The process of the final evaluation and its results can be seen in Chapter 6.

5.5 Features

Some of the application's features were more impactful than others, either affecting the user needs, research questions or just being technical core functionality. This section will elaborate on the implications and thoughts behind some of these features. All mentions of requirements, "R#", refer to the requirements listed in Table 4.5.

5.5.1 Environment Interaction and Movement

To get the most out of VR's potential we wanted to have a realistic world the users could interact with and freely move around in. Not only to increase their sense of place presence and co-presence [15], but because having the ability to freely roam space and control one's own pace is shown to increase motivation [62]. This theory is further supported by the application's lack of constraints in general and not having specific tasks to complete.

The users are able to pick up objects in the environment, throw them, stack them, pass them to each other and most other things they can think of. This freedom was thought to increase creativity, which is an important aspect in constructivism and especially experiential learning [63]. Furthermore, as mentioned in Section 2.1.4, an increased sense of presence and interactivity will also increase the feeling of immersion.

The environment itself went through several changes, most of these were to make the forest more Norwegian and to fill it up with more objects. A goal of the application was to give a feeling of Norwegian culture, which we tried to replicate when designing the forest. We also got several request of adding more and more interactable objects to the world as these were the most engaging parts in the application. A comparison of an early version of the forest and the final one can be seen in Figure 5.7.

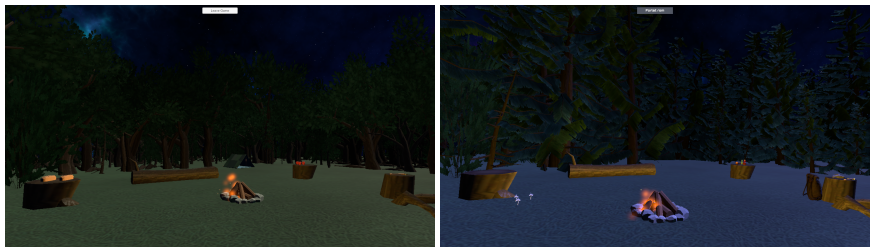


Figure 5.7: Screenshots of an early forest environment (left) and the final version (right).

users move around in the virtual space by moving in the real world with a one-to-one mapping of the movement. But the forest or café is larger than the real space. To circumvent this, we let the users teleport freely around in the environment with a press of a button. This is the common way to solve this problem in VR applications. Users found it a bit confusing when other users teleported, as they would see the person they were interacting with just disappear with no feedback to where and even that they teleported at all. To fix this lack of feedback, we added a trail of light particles following the teleporting player for a short time, allowing the other users to follow the direction with their own eyes. This increased the users' awareness of where the other users were in the virtual space, as described in Section 2.1.5. Screenshots from both teleporting oneself, as well as the particle trail can be seen in Figure 5.8.

When picking up an object, the user can see the Norwegian word for that given object and hear the pronunciation of that word, see Figure 5.9, aiding with both learning new vocabulary and pronunciation. These features also answer system requirement R3 and R8 (see Table 4.5), by encouraging object interaction with little constraints.

Figure 5.8: Screenshots of users teleporting, from the teleporter's point of view (left) and the particle trail following them (right).

Figure 5.9: Screenshot of an orange being held in the application with its Norwegian word visible.

5.5.2 Avatar

How the users were represented in the world was especially important, as one of the most important aspects of the application is social interaction. To support this, we wanted it to be easy to see other people and understand where they were looking. The struggle between realism and functionality is also important. We wanted to have a simple design to avoid the uncanny valley, give new identities to the users, and only contain the information needed to properly communicate and differentiate each other, as described in Section 2.1.6.

As a first draft of a design, we had a simple human head on top of a capsule with gloved hands where all users' avatars were the same, only differentiated by their colour and nametag above the head. We got comments on the design being creepy, boring and too masculine as we used a male head. We then revamped the avatar, making it look like a cartoonish humanoid robot. This fixed the creepiness by making it more cute and less human, in other words avoiding the uncanny valley. It was not boring anymore, as both the head and torso had many small details compared to only two simple shapes. Finally, the problem of the avatar being a man was also solved by making it a genderless robot. The change between the two versions can be seen in Figure 5.10.

With the limitations of the hardware only tracking the head and hands, we settled on not having arms and legs on the avatar. We got some comments on this being weird at first, but nothing big and could not find a solution to this by talking between ourselves and

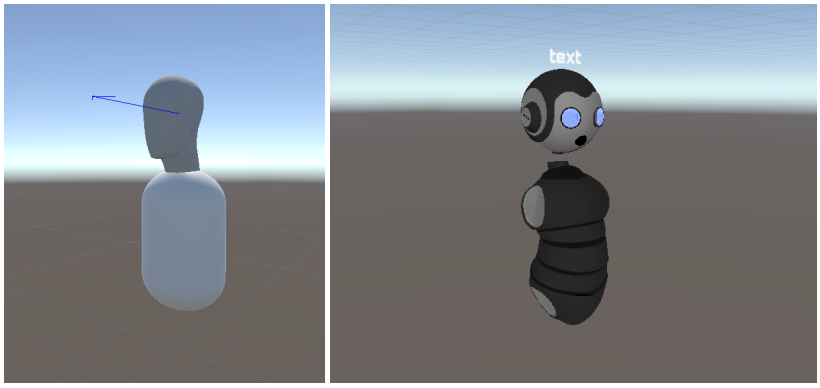


Figure 5.10: Comparison of the first avatar (left) and final avatar (right).

the users. Even though this fault did reduce immersion sometimes for some people, it did not seem to affect the social interaction which was most important. Jerald [12] actually supports this choice, as having legs and arms that are not properly tracked would look unnatural and break immersion. We also noticed that people did not notice the missing limbs after interacting with each other.

Only having one avatar and no customisation options was met with complaints. People wanted to represent themselves and show other who they were. This would increase immersion as you would feel more like yourself, and could make the whole experience more enjoyable. Optimally, we would implement a set of variations of head, hats and torsos similar to Second Life and VRChat, but given the lack of resources we had to settle on having one avatar that they could change the colour of. This was a slight improvement, but we would still receive comments on wanting to have more customisation.

This functionality would together with the avatar answer requirements R4 and R5 concerning the virtual avatar, and communication and interaction respectively.

5.5.3 Voice Chat and Communication

One of the most crucial aspects of the application was to support collaboration between the users. As we mention in Section 2.1.5, there are three components for collaboration: communication, awareness and proximity. For communication, speech was the most obvious solution, as we wanted to simulate the real world. We therefore added voice communication with the addition of spatial attenuation. By doing so, we had a semblance of awareness by making it easier to keep track of conversations. Awareness is further enhanced by adding spatial attenuation as it could give the direction of the sound and information about other users' position in the virtual environment. Also, as a user received information about where the sound is coming from, they can also tell the difference of who is talking. This spatial feature also plays a role in the feeling of proximity as the sound is affected by distance, the volume of the sound becomes lower the further away someone is. This property can also increase immersion.

We were also aware when designing the avatar, that body language and eye contact are important parts in communicating. Given the restraints of the hardware, we could not replicate facial expressions and accurate and detailed body language. Because of this, we had to settle for simple hand movements, the direction people are looking at and simple simulation of mouth movement. Despite these limitations, we later received feedback on the body language being surprisingly effective, see Section 6.1.3.

5.5.4 Dictionary

To help in learning new vocabulary, how to pronounce words and to answer requirement R12 of revisiting words encountered, the dictionary was designed. Whenever a user picked up a new object, the name of the object would be added to that user's dictionary. Then, at any time, that user could open the dictionary and see a list of all the different words of the objects they had picked up. By clicking on one of two buttons assigned to each word, they could either listen to the pronunciation or use voice recognition to add a new instance of that object. A screenshot of a partially filled up dictionary can be seen in Figure 5.11.

Figure 5.11: Screenshot of the in-game dictionary

The dictionary was built on the user needs of pronunciation and vocabulary, and was developed together with the end-users to be as simple as possible while keeping the most important features. Seeing the list of words and listening to the pronunciation is supported by audio-lingualism [28], as well as the common knowledge that practice is fundamental for language learning. The voice recognition feature where the students had to say a Norwegian word correctly also supports practising pronunciation. The reward of creating objects out of thin air can further encourage students to speak Norwegian, as well as increase their vocabulary.

We wanted to encourage the students to walk around and explore the environment, so the different words were not available in the dictionary until they had picked up the object wherever it was in the world. This is also good in accordance to Kiili's experiential gaming model giving the students open tasks to get them into the flow [33].

5.5.5 Voice Recognition

There were several challenges when implementing voice recognition into the application, explained in Section 5.6.3. It was fixed in the final stage of development. We chose to keep it simple and similar to how both the end-users and us imagined it in the beginning: creating new objects when the Norwegian word was pronounced correctly. As mentioned in the previous section, this was meant to give the students practice and feedback (requirement R7) as well as a reward for doing so. During user testing, we found out the reward was so efficient that even the teachers used this method to add objects, even though they could do it with only a single press of a button as it was more fun. The voice recognition in use can be seen in Figure 5.12

Figure 5.12: Screenshot of voice recognition in use. Translated from Norwegian: “Voice recognition started, say the word: An apple” “Time remaining:”

A negative feature, surprisingly, was that the Application Programming Interface (API) we used (Google’s) was to kind; it was too good at interpreting what was said. Sometimes when a teacher would have said the pronunciation was wrong and give corrective feedback, the voice recognition accepted the query and creates the given object. But, given the limit of the technology as well as the focus on contructivist teaching, we found the end result sufficient for our needs. In addition to this, the service also requires payment, charging for time used, which could be costly in length. We also made contact with a Norwegian business, Capeesh, working on exactly this; giving accurate, correctional feedback on specific Norwegian sounds and pronunciation, but they did not have a public API.

5.5.6 Teacher Mode

Given the need of teacher inclusion and the following requirements R8 and R9, of creating task-based instructions and having teacher tools respectively, a teacher mode was created. To access it, the user had to check that they were a teacher and write the teacher password “lærer” when starting the application. Security was not concerned at all, as the only reason for having a password was for students not to log in as teacher and using the additional power to misbehave in classes.

The teacher had all functionality the students had, but with a few additional tools. First, they could turn invisible; this was done to give them the opportunity to observe their

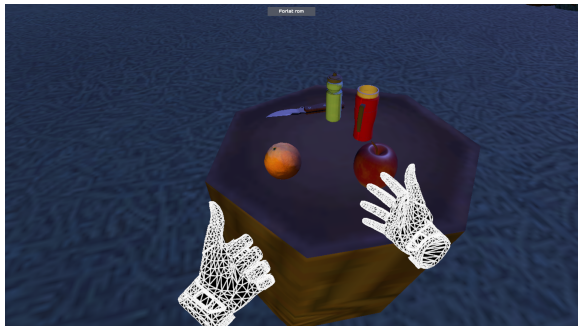


Figure 5.13: Screenshot of a invisible teacher from their point of view. Other users will not see anything in their place.

students without interrupting and disturbing them, the result can be seen in Figure 5.13. The teacher had access to all interactable objects implemented and could add them to the world at will, as well as change the properties of the objects in the world which helped them customise the classes and create tasks. The words visible on all interactable objects could be turned off to increase difficulty. Finally, they could save and load world states. Which meant that the teacher could prepare tasks and classes in advance and when needed, load them into the world. This final feature also worked as a way to reset the room if something went wrong or the room became messy. The ability to reset the room was used several times: the sprint tests, planning the session to be used during the final evaluation, and during the final evaluation itself. Screenshots of both the teacher's dictionary and the settings screen can be seen in Figure 5.14.

Figure 5.14: Screenshots of the teacher's dictionary (left) and settings menu (right).

5.5.7 Tutorial

All user testing we did before the final evaluation was done with us present and able to walk the users through the controls and existing features. In the end product this would not be possible resulting in the tutorial. It was set in an abstract world, containing a sign with instructions and explanations of what to do and little else to keep it as simple as possible. The virtual hands were replaced with a representation of the controllers being held with labels on the various relevant buttons and their functionality. The tutorial explored all

functionality step by step while guiding the user through every feature and button they should know. Both students and teachers had the same tutorial up to a point where the students finished and the teachers learnt their additional teacher mode tools. Screenshots from the tutorial can be seen in both Figure 5.15 and Figure 5.16.

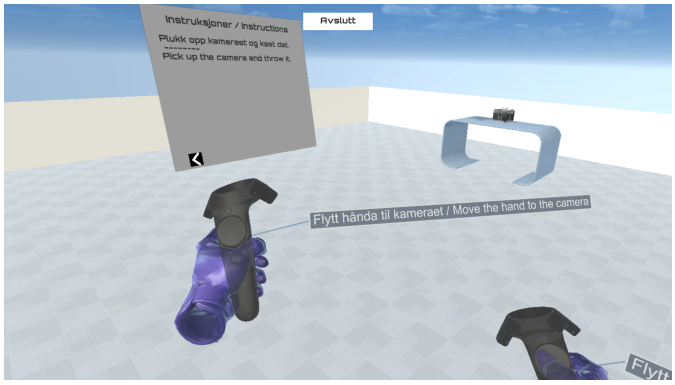


Figure 5.15: The tutorial space.

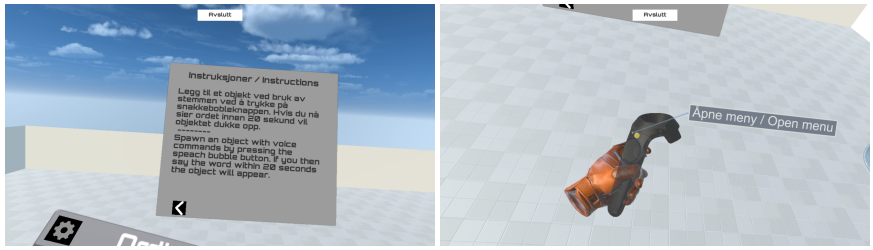


Figure 5.16: Screenshots from the tutorial: the instruction sign (left) and button labels (right).

This was done to fulfil requirements R1 and R10; of being usable in a classroom setting and easy to use. As there is no point in having many good features if the user cannot properly utilise them. Seeing as this technology is foreign to most users and they are wearing a headset blocking sight of the real world when in use, we needed to teach them the controls in some way. In the actual application, there is no mapping between the controllers and the hands; not to mention the interaction with the in game menu. This results in poor affordance, as described in Section 2.1.6. If the user have not used the HTC Vive (or the Oculus Touch controllers) they will not even know certain buttons exists. A tutorial was therefore absolutely necessary. After getting to know the controllers and its buttons, we found having only the virtual hands (without representation of the controllers) was better and not confusing. This was true as feedback of actions was now more important than the mapping of the controllers. These design principles are described in Section 2.1.6.

Since the goal of the application is to teach Norwegian, the interface is all in Norwegian. This could be a problem in the tutorial as every bit of information is vital to understand how to use the application. We therefore had all instructions in both Norwegian and

English, except the teacher mode instructions which were in Norwegian only.

The tutorial consisted of several steps, guiding the user through all relevant controls and features. This was done through step-wise instructions on a sign in the room, which would update as they were completed, i.e teleporting, picking up objects and then interacting with the menu.

5.6 Challenges in Development

This section will list some of the most challenging features to implement, the work that had to be done to get them into the application and reasons behind our choices.

5.6.1 Multiplayer Challenges

One of the essential features we worked on our application was multiplayer. The application is meant for collaboration between multiple users, so it had to enable them to see and interact with each other in real-time. In the beginning, it seemed simple enough as Unity had their own supported way of implementing multiplayer called "UNET" [64].

There were problems we met during this time. The set up for UNET was more difficult than we first anticipated even with the documentation. To connect players they would first need to connect to the game server, then connect to each other via a lobby system. However, the players could not see each other in the lobby and were therefore unable to connect.

Another, more major, problem was a future Unity update to soon change how UNET work; changing how Unity interact with their multiplayer services. It would still be supported up to version 2018.4 and some years after the release, but this future deprecation motivated us to look into other alternatives.

In the end, we found a third party plugin called Photon Unity Networking (PUN), made by Photon [65]. The plugin handled the communication with Unity's networking services and at the same time supported another feature we knew we would need later on: voice chat. The implementation went surprisingly well and we had it up and running with no major issues.

It was easy to think that the multiplayer functionality was settled, but new issues would arise throughout development as our needs became more complex. Synchronisation was a big problem for a while. Everything a player did in the world needed to be seen and synchronised to the other players. Most of our issues in later development was because we were using a rather new product. PUN 2.0 was a product we chose because it seemingly fixed our problems and we wanted the newest features. At the same time, it was still at an early stage, which meant it was not fully developed. Because of this, many problems we had, did not have answers yet. This meant that we needed to experiment more on our own and also dig for answers. Luckily, we found out that Photon had their own forums where the developers of the plugin were quite active. There, we made an account which we used to ask questions for specific issues. This helped us get the features we wanted faster while helping them finding bugs and missing features.

Despite this, there are still issues that linger in the application. Not necessarily because of the PUN plugin, but because of more complex issues. The two issues we made note of was the synchronisation of the players' hand animation and colours on objects. The hands are a part of another plugin called SteamVR which handles much of the necessary setup to enable VR development in Unity. Unfortunately, it also meant a lot of what was done in the background was unknown to us. This included hand animation, as it did not use the default animation feature that Unity uses, but rather controller actions moving the skeleton. While the colour issue was something that became apparent when we introduced a feature that enabled teachers to change attributes of an object and saving and loading of environment. When loading the environment, there were times when not all of the colours would synchronise properly for everyone in the environment. This was something we found out about during the end of our development time so we were not able to look at a solution for this.

5.6.2 Voice Chat Challenges

When we researched different multiplayer APIs we also found out that Photon had a product for voice chat, Photon Voice [66]. It was a natural choice since Photon Voice came with similar features that PUN had, such as: simple set up, being hosted on a cloud server, easily integrated into Unity and easy to integrate with the existing PUN framework.

Similar to PUN, the issues that would arise with voice chat was not obvious when we first started. There were already difficulties when first implementing it, but at the end of the second sprint it seemed to be working. That was until the following sprint, where we found a new use case where it would not work; an issue where the players were not able to hear each other. There were different variations of this issue: the host could be the only one hearing others, no one could hear anyone, or there was a single player who could not be heard. We were able to track down the source of the problem most of the time and they were either our fault or a fault in the plugin. Either way, when trying to fix this we remained in contact with Photon and were active on their forums. We were able to fix most of them, but there was one error that kept showing up on specific circumstances that we did not have time to work on. If a user started the application without a microphone, and later on connected the microphone, the application would not detect a microphone. Fortunately, this had a simple solution which was to simply restart the application, but it was still a minor inconvenience.

5.6.3 Voice Recognition Challenges

Voice recognition was a feature we were excited about, but as we looked at our alternatives it became more grim. Unity makes use of plugins to integrate functionality the development platform does not have. There were two ways of including these plugins: you could find them in the Unity asset store where someone else has already made the plugin and enabled integration with Unity, or you can make your own plugin. Making a plugin for Unity was something we had no experience with and meant greater risks since we could end up with using a lot of time in something that does not work. Because of this we started browsing the Unity asset store and quickly found that the existing plugins were lacking.

The voice recognition functionality we needed, had to be some form of streaming, as it was meant to be used in the background while you are in the virtual world. Not many plugins supported a streaming version and more importantly, few supported the Norwegian language. We could only find one that had an open API, could handle streaming input and supports the Norwegian language: Google cloud's speech-to-text. At the same time, choosing the Google cloud service meant that we had to create our own plugin to integrate it with Unity, as there was no existing SDK or standard way to do it. We tried, but ended up with one major error: for some reason, the plugin caused Unity development platform to freeze if it found a match with what was said and the word it was looking for. This issue followed us from sprint 3 to sprint 5, during which we talked to both Google's and Unity's support service to try and find a solution. Thankfully, Unity support service found a solution to the problem, but at that time we were close to the end of our development period.

Seeing as the solution was found so late in development, two-three weeks before our deadline, we did not have much time to do anything with it. Initially, we had several plans for this feature. One of them was to have a passive way to give points to users who spoke Norwegian rather than English, in a hope to motivate use of the Norwegian language. We also wanted to extend the feature so that it could give some form of metric for the teacher by registering what words the students had difficulty with. Sadly, all of these ideas were no longer feasible to implement. However, since we already put so much effort into it, and it had such potential in a language learning application, we decided to add a simple feature. The voice recognition could be started on each word in the in-game dictionary, if a user said the word and the voice recognition was able to understand it then an object would be created in front of the user. It was an enjoyable feature to use, but ultimately was not evaluated in the final evaluation.

Chapter 6

Evaluation

This chapter will explain the design process and planning of the final evaluation as well as the evaluations done preceding it. We will then present the evaluation results.

6.1 Data Gathering Outside of the Final Evaluation

These tests are not part of the final evaluation, but some of the findings are relevant nonetheless, we therefore found them important to include. The tests include the sprint tests that were briefly described when talking about the sprints in Section 5.4, one big test done in relation to the ISFiT, as well as attendance at several conferences and forums.

6.1.1 Sprint Tests

Even though the sprint tests, as described in Section 5.4, was mainly for including the end-user in development in accordance to the user-centred design [11], some findings went beyond that. We will present, what we mean is, the most important results from these tests in regards to the evaluation of the application. All of these tests were performed by telling the participants the idea of the application before letting them test it with a focus in the newest features and finished with a semi-structured interview. The interview was changed between sprints, but was in general about the new features, the application in general and their thoughts about the concept. The interview guide for sprint 2 can be seen in Appendix A.4.

From the very first version of the application, the feedback was that the controls were easy, in general. A few of the users had a lot more difficulty using the application. These users seemed to be older and with little experience in technology. The ones who got the hang of it the quickest were people who played games regularly, as they were used to controlling a virtual avatar using some sort of controller. This held true all the way to the final version of the application.

The forest was always described as pleasant, realistic and aesthetically pleasing, and was well received as a main environment from day one. But, most people had a second or third environment they wanted to see: i.e a bar, café, kitchen, infirmary or the streets of Trondheim. Showing, as we mentioned in Section 1.2, one of the strengths of VR is one can virtually be anywhere.

The tests in sprint 1 and sprint 2 included a system usability scale [67] to roughly measure the usability of the application. This was not done on later sprints as we did not have a sufficient amount of testers in those tests. Sprint 1 had a weighed score of 60.4, while sprint 2 a weighed score of 74.5. This shows an improvement of usability and the latter is considered an above average result [67].

6.1.2 Stand at the International Student Festival in Trondheim

During sprint 4, the 11th of February, we were invited to ISFiT to showcase our application to visiting students from all over the world. We took this opportunity to get feedback from more people than we had access to during past sprint tests. We could not interview people as we would have two VR-setups with the HTC Vive and people would drop in and out during the day. Instead, we made a questionnaire which can be seen in Appendix A.5. As we did not have any information of who the participants were, other than students coming from all over the world visiting Norway for the festival, we could not know in advance how valuable the data collected would be and had to get some context from the respondents. The main purpose of the questionnaire was to find out if they believed in the use of such an application in learning languages, if it was motivating and how to improve it, given it was not the final version. A photo of the application in use can be seen in Figure 6.1.

Figure 6.1: Photo from user-testing at stand during ISFiT.

This was done during development, meaning the application was lacking several key features present in the final version. There was no teacher mode, but this would not be noticed as they did not test with a teacher, no tutorial and only had the forest environment.

We ended up with 30 questionnaires, all with at least secondary education (21 having a Bachelor), coming from 24 different countries. No participants had any Norwegian language education, but as all of them had learned at least one secondary language we deemed them relevant enough for our research. We did not have tasks to complete or a plan to follow during testing, we explained the controls and existing features to the participants. Afterwards, they got to explore on their own terms before answering our questionnaire.

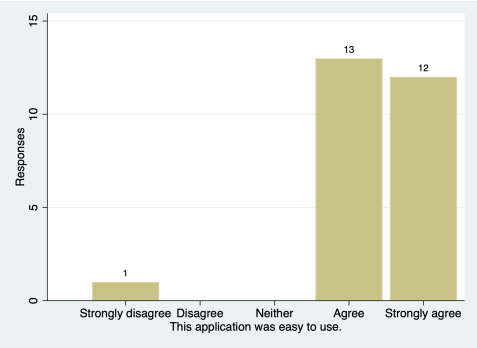


Figure 6.2: Results from ISFiT asking the application was easy to use.

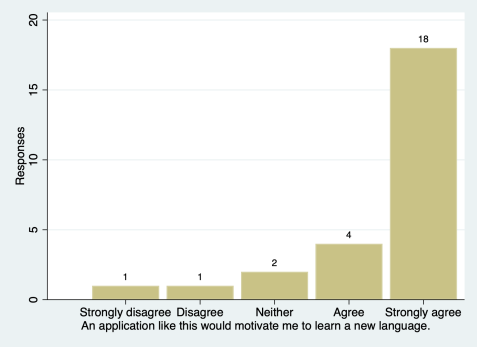


Figure 6.3: Results from ISFiT asking if an application like this would motivate to learn a new language.

The participants found the application both easy to use and believed it could be motivating when learning a language, as can be seen in Figure 6.2 and Figure 6.3 respectively. When asked if they wanted an application like this, both in the classroom and during their free time, they were positive. Four participants did not answer these questions and the statistical analysis was done using Wilcoxon matched-pairs signed-ranks test with Stata: Software for Statistics and Data Science [68]. There was a significant difference ($p = .099$) and we can see in Figure 6.4 that they were more positive to having this application outside of the classroom. They did not test this application with a teacher present which could explain these findings.

18 of the 30 participants had used Duolingo previously as a language learning tool

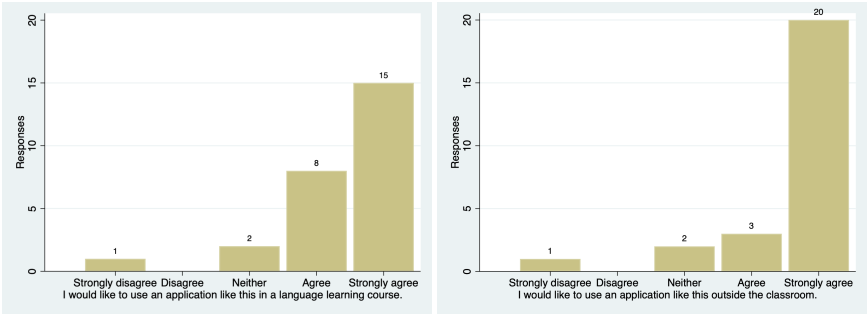


Figure 6.4: Results from ISFiT asking if they would like an application like this in the classroom (left) and outside the classroom (right).

and only six had not used any tool at all, supporting the popularity claimed by Seave, Ava [47] mentioned in Section 3.1.2. Nine had used VR before and only one had used it in an educational setting.

What was your favourite aspect of the application?	Responses
Interacting/communicating with other people	8
Fun	5
Interacting with objects	5
Immersive / Real	3
Brings something new to the otherwise boring classroom	3
Simple	2
A real person	2
Pronunciation of words	1
A safe setting	1
The nametag	1
Well developed	1

Table 6.1: Coded results from ISFiT on their favourite aspects of the application (18 responses).

When asked what their favourite aspects of the application were, the most popular answer was the interaction/communication with other people, followed by fun and interaction with objects. What they wanted to change and improve was mainly hardware issues, such as better graphics and a more comfortable HMD. Adding environments and more objects were also mentioned several times, which was added after this test. The full results from these questions can be seen in Table 6.1 and Table 6.2.

6.1.3 Other Conferences and Forums

In addition to these more planned evaluations, we attended various conferences and forums where we showcased our application and got informal feedback from experts. ISFiT was already mentioned, but the final evaluations done in Gjøvik was also done in coordination

What would you change or add to the application?	
Better hardware	6
New environments	3
Add stuff for more realism	2
Add some other parts of the body (More human)	2
More interaction with objects	2
More grammar	1
More objects	1
Have goals/tasks	1
More accessible for people	1
Pronunciation of all words	1
Other languages	1

Table 6.2: Coded results from ISFiT on changes wanted to the application.

with a conference. It was about VR and AR in general and we presented and talked about our application to interested IT-companies such as Microsoft and Bouvet.

We attended two additional large conferences after the completion of the application. The first was National Conference about the usage of IT in Education and Teaching (NKUL) held in Trondheim, where new technologies to be used in education were presented and teachers and school personnel from the whole country came to see and discuss possibilities. We showcased our application and talked to the teachers trying it out. The feedback here was really positive, ”This is exactly what I need with my adult immigrants!” said one teacher working in adult teaching for immigrants before he brought up several similar use cases with different locations and objects and how this was something he would wish to have in his classroom sometime soon.

Then, we showcased the application at the Digital Competencies for Language Teachers (DC4LT) forum in Brussels May 2019, in which this project was a part of. Here, 20-30 experts in language teaching, i.e teachers, administrators and researchers, gathered to present findings from research done and have an open discussion on the state and future of digitalising language teaching. We presented our findings here, but primarily showcased our application and talked about our experiences using it with both teachers and students. These experts were also interested and positive on the work done, some of them travelled for the sole purpose to check out this “collaborative VR application for language teaching” and most of them said it was the highlight of the forum.

Links to web pages with more info of these conferences can be seen in Table 6.3.

ISFiT	https://www.isfit.org/
Gjøvik	https://innsida.ntnu.no/kalender/detaljer/-/event/00b61710-be9b-3271-8eaf-7b9128f0482c
NKUL	https://www.nkul.no/
DC4LT	https://www.dc4lt.eu/the-digital-future-of-language-education-forum/

Table 6.3: Table of conferences attended and links to more information

A short time after Brussels, a demonstration was held for a group of people from

Statped, which is the governmental special needs service for municipalities and county municipalities. They wanted insight into how VR can be used for education with students who had disabilities. During this event, people who had hearing impairment were brought to try out the application. The feedback we received were positive and they were interested in further development on our application and new applications as well. Those with hearing impairment were also surprised and impressed by how much they could communicate with other people in the environment. Even though the means of communication was simple, with only hand movements, they were quite satisfied with it. An interesting comment we received was that they said there was a lot of body language they could interpret from other users. Which is a different perspective than what we heard from the Norwegian language teachers. One of those who participated speculated that this was because those who had hearing impairment often notice completely different details than other people. This ability is seen as a great strength in such a visual medium.

6.2 Final evaluation

The final evaluation contained several aspects which needed to be prepared before execution: the questionnaires, interview, location, hardware, participants, the test itself and other details. In this section, we will try to explain the choices that were made, and why and how we did them.

6.2.1 Practical Details

The final evaluation was to be run with two teachers from NTNU, two teachers from Lukas vgs, students at NTNU, some attendees at a VR conference in Gjøvik and pupils from Lukas vgs. The number of participants was not fully known in advance, but we wanted to separate the tests over three days: two with participants from NTNU and Gjøvik simultaneously, and a third with participants from Lukas vgs. This would make it easier to find days fitting for participants as well as giving all teachers roughly the same amount of usage.

Each test run should have one teacher as well as between three and seven students and last between 15 and 30 minutes. The time available for the students and how many there were would determine the time spent in VR. It was therefore important to have a flexible test plan.

The first two tests would be run with the teacher and some students in Trondheim in addition to some participants in Gjøvik. Both locations needed to have multiple VR setups and ended up having four HTC Vives in Trondheim and two HTC Vives in Gjøvik. The last test was simultaneously at NTNU Dragvoll and Lukas vgs, separate locations in Trondheim. This test had four HTC Vive setups as used in the previous ones, but at Lukas vgs they only had Oculus Rift setups, which we used four of.

The application was required to support up to eight people and to let users connect from wherever in the world, see Section 4.4.2, with this setup we got to test this out to some degree.

In the end, we ended up with four teachers and 25 students. Two tests with one teacher and five students each, one test had a teacher and seven students and one with a teacher and eight students. The first two where with NTNU, the last two with Lukas vgs. A test in action can be seen in Figure 6.5.

Figure 6.5: Image of two participants' view during the final evaluation.

6.2.2 Design of the Norwegian Language Lesson in VR

We wanted the participants' experiences when trying out the application to be similar to what it could be in an actual Norwegian language course. To achieve this, we gave the Norwegian teachers at NTNU Dragvoll freedom to play with the application in preparation and together come up with a roughly 10 minute session using most of the functionality the application offers. In addition to the 10 minutes of activities, we wanted to have five to ten minutes of the participants going through the short tutorial and playing around freely in the environment. The idea of this was to give the students time to get to know the controls, the environment and each other. From our own experiences, we knew that the novelty of trying VR for the first time is distracting and people really want to just play around this new and virtual space. We believed giving them time to do this before the assignment was crucial for everyone's enjoyment. Letting the teachers model their own teaching session was important for us, as teachers bring their own experiences to education and is an important aspect in constructivist pedagogy, see Section 2.3.

What the Norwegian teachers came up with were two activities to be performed after everyone had gathered and introduced themselves to each other (around the fireplace or a table). These activities had a goal of teaching prepositions as the teachers found that it was the most logical thing to learn in a virtual application with a lot of spatial freedom.

To prepare the first activity, the teachers placed many objects of different types, sizes and colours on a table in the environment. During the test, the students would be asked to move certain objects in relation to other objects with the goal to learn some new vocabulary, adjectives and prepositions.

Activity two was prepared in advance by the teachers hiding various objects in the environment and then during the test, telling the students, in Norwegian, one after one where it was hidden as a way to learn prepositions. After the student found their hidden object, the other students were supposed to ask yes and no questions to figure out what the object was, again, as much as possible in Norwegian.

They made the whole session flexible by hiding more objects than they thought were needed, having activities not dependable for each other and not having activities requiring a certain Norwegian level or a number of people. When they suggested this idea to us, we saw it fit into what we talked about as being one of VR's strongest pedagogic assets: experiential learning, see Section 2.3.3.

6.2.3 Questionnaire

During the final evaluation we made use of two questionnaires. One was to be answered before the VR session starts (mainly for mapping the context) and one afterwards (getting feedback on experiences in the application).

A metric we made use of in both questionnaires was the self-efficacy scale. Bandura [41] describes perceived self-efficacy as "people's belief in their capabilities to produce given attainments". The intention was to use this scale as a measure of motivation, as measuring motivation is seen as a great challenge and there is no general way of doing so. Some are even debating against using self-efficacy as a measurement for motivation. However, even if self-efficacy is not directly linked to motivation it is still an important metric. According to Bandura, perceived efficacy plays a key role in human functioning because it directly affects behaviour. It also impacts one's goals, aspirations, outcome expectations and opportunities in the social environment [41]. When creating our self-efficacy scale items, we made use of Bandura's guide for content validity, though we did not use the same structure on the scales. Instead of a response scale ranging in 10-unit intervals with 0 to 100, we had a five option Likert scale from stronly disagree to strongly agree. This was because we felt it would be easier for our participants to answer and leaving less room for confusion.

The questionnaire before the VR session, the pre-test questionnaire, gathered general data: gender, age and how long they have been learning Norwegian. It also asked about their opinions on VR as an educational tool and if they have tried anything similar before. This was to map the student's attitudes towards VR, as recommended by Molka-Danielsen and Deutschmann [20]. Mainly to see if the attitudes affected the answers e.g negative attitudes led to negative answers and vice versa. Lastly, there was a set of self-efficacy statements at the end related to their performance in a language learning classroom and mastery of technology. An example of these statements is "I am confident that I can hold a short conversation with another person in Norwegian". For the statements, we took into consideration the Norwegian teachers' suggestions on what we should ask. For example, they recommended to ask about how comfortable the students were in relation to the teacher and speaking up in the classroom. The pre-test questionnaire can be seen in full in Appendix A.6.

After the VR session we had a longer questionnaire, the post-test questionnaire. At this point, the participants had experienced the application and we were interested in their

opinions about the features (the environment, objects, sound, user avatar etc.). The focus was on their interaction with these features and if it helped them in any way. The closed questions were presented as Likert scale questions. With questions where it was difficult to create a statement for the Likert scale, we made use of open questions to give participants freedom to answer more in-depth. Similar to the pre-test questionnaire, the last set of questions concerned self-efficacy. Unlike the self-efficacy statements in the pre-test questionnaire, this one was related to VR. An example is "I am confident that I can hold a conversation in Norwegian with another person who is using a virtual avatar ". The post-test questionnaire can be read in Appendix A.7.

Some of these self-efficacy statements were the same, only in different settings. The pre-test questionnaire was in relation to a traditional classroom and the post-test questionnaire was in relation to VR. This was to compare and see if there were any significant differences on the answers concerning the setting. The results from these questionnaires can be found in Section 6.3.1

6.2.4 Interviews

We only made questionnaires for the participating students. For the teacher we performed interviews, as we had more time and better communication with them and wanted to get more detailed and in-depth data. Optimally, we would interview the students as well, but with the amount of participants expected and resources at hand, this was not possible.

Similar to the student questionnaire, we asked about the comparison between this virtual session and a regular classroom. In addition to the experience in VR, we could now also ask about the experiences that came when brainstorming and preparing the session, as described in Section 6.2.2.

The interviews were performed with one teacher at the time, a few days after they had participated in the test. They were semi-structured in nature and lasted roughly 30 minutes each. The focus would be on the teachers' experiences from the view of a pedagogical expert and contained questions from both the final test as well as their experience in collaborating on this project. The interview guide we followed can be seen in Appendix A.8 and its results in Section 6.3.2.

6.2.5 Observations

While the participants were in the VR session, we also observed them. These observations were done loosely, but were focused on how they interacted with each other and challenges they met during these sessions. Some examples of these interactions would be how they would greet each other or any feelings they expressed during their experience. The challenges could be hardware issues, difficulties with controls or because of a lack of features. In addition, we had some casual conversations with participants after the evaluation, some of which were relevant to this study. The notes from these observations and conversations is to be used to further support findings from the questionnaires and interviews and fill in the gaps these could not cover.

6.3 Results

In this section, we will go through the results from the evaluation. We will be presenting the initial findings found in the data from the questionnaires and interviews.

6.3.1 Questionnaire Results

The questionnaire was divided into two parts: pre- and post-test questionnaire. We will separate the results from each questionnaire in this section as well, before presenting connections between them. Half of the questionnaires were translated from English to Norwegian to better suit the participants from Lukas vgs, we will not differentiate on the basis of the questions' language. 25 participants answered the questionnaires, even though not every question were answered by everyone. Open-ended questions have all been coded and the relevant results are listed as tables in this section, the number of responses varies as mentioned, but are all listed on the corresponding figures. It should also be noted that when coding, a response from a participant might be relevant to more than one category, in those cases it will be added to each category it fits in. Some statistical analysis has been done, we have used Wilcoxon rank-sum and Wilcoxon matched-pairs signed-ranks test using Stata: Software for Statistics and Data Science [68]. The ten participants from NTNU had at least secondary education, but we can not say with certainty that the 15 from Lukas did. We asked the teachers who gathered them for us that we were only interested in students with at least secondary education and they believe they managed to find so, but were not quite certain.

Pre-Test Questionnaire: Getting Context

An important goal of the pre-test questionnaire was to give some context to our student participants. Such as if they have ever tried VR before, age and gender. There was a good coverage on all parts with 13/12 (Male/Female) and age ranging from 22 to 57 years old, even though most participants were in the range of 22 to 32 years, the results can be seen in Figure 6.6.

When asked if the participants believed in the use of VR in education and language teaching they were very positive, as can be seen by Figure 6.7, with only one or two participants saying they did not believe in the technology in this context and 70% to 74% believing in it.

14 of 29 respondents had tried VR before, but of them only one had more experience than only testing it for a few minutes. With one exception, who had been part of the project at earlier tests described in Section 6.1.1.

Every participant had some degree of Norwegian education, ranging from under 1 month to over a year. Most of the participants from Lukas vgs had over a year of experience (12 of 15), while at NTNU most had between 1 and 6 months of experience (5 of 10), see Figure 6.8 for the full results. This split degree of Norwegian knowledge did not prove to be a problem, as the groups that tested together were at a similar level, with one exception, elaborated in Section 6.3.4.

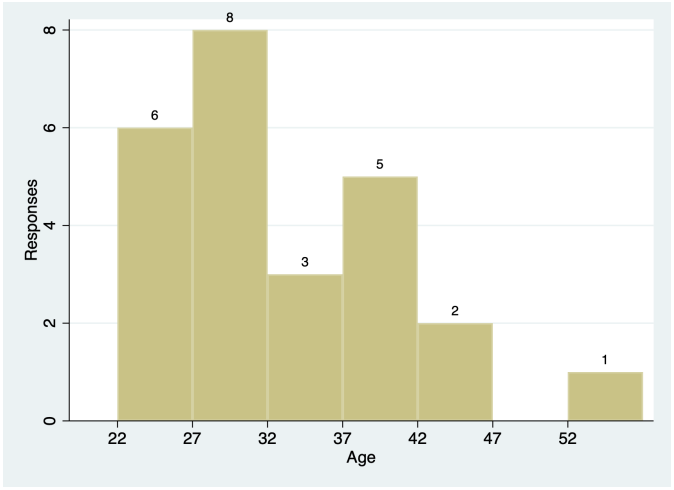


Figure 6.6: Age of participants.

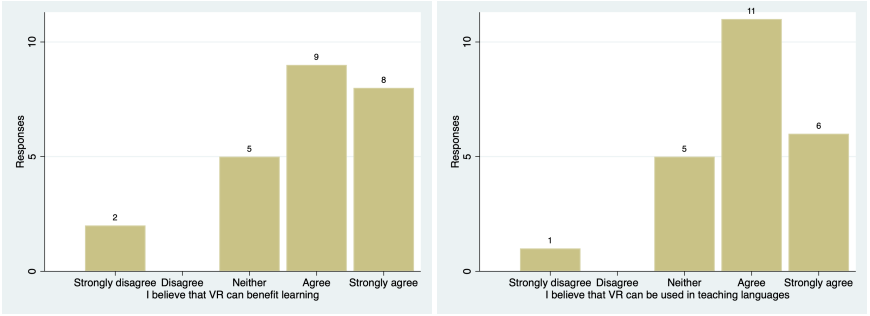


Figure 6.7: Responses when asked if the participants believed VR could benefit learning (left) and if it could be used in teaching languages (right)

Results from the self-efficacy statements show that the participants were, in general, quite confident in their own ability to participate in a Norwegian class, learn new technologies and use basic Norwegian as can be seen in Figure 6.9.

All open questions have been coded by trends in the answers. When asked why they believed VR could be used in teaching languages we got many answers. The coded results can be seen in Table 6.4. The question also included why they did not believe if that was the case, which has not been included in the table. As Figure 6.7 shows, only one participant did not have belief in the use of VR in teaching languages but we got an additional response as to why they did not believe in VR in language teaching. Their main concern was their struggle of playing games and were worried this might carry over to the use of VR applications, as well as the limitations of the technology today. The overall results of this question show that the most attractive features of VR in language teaching are: the interactivity, fun and correlation between images and their words.

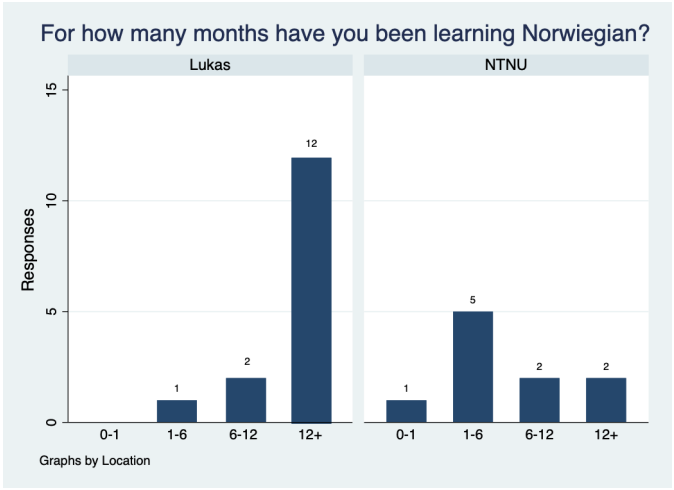


Figure 6.8: Responses to how long the different participants had learned Norwegian, separated by location. Lukas vgs (left), NTNU (right).

Why do you think VR can be used in language teaching?	Number of responses
Interactive/fun	3
Linking words and images	3
Encourages learning	2
Change of environment	2
Simulate situations	2
A new way of communicating	2
Safer	2
Connects content and emotions	1

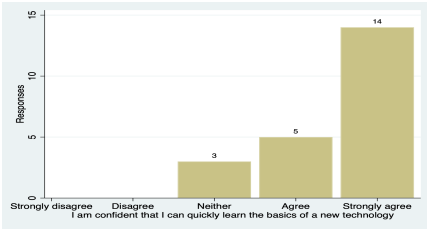
Table 6.4: A summary from post-test questionnaire of participants' answers to why they believed VR could be used in language teaching, if they believed it could (16 responses).

Post-Test Questionnaire: Experiences From the VR session

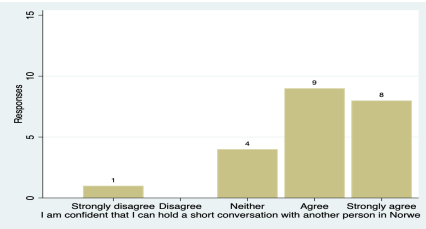
The results from the questionnaire were strongly positive in general, as can be seen in the answers from "I felt I was in a forest/café", where 87% agreed, and "Seeing the name of the objects when holding them helped me learn the words" which can be seen in Figure 6.10.

When comparing VR to a regular classroom most people felt more at ease and more motivated in the virtual world. The left graph in Figure 6.11 show the activities in VR being far more engaging than similar activities in a regular classroom with 75% agreeing. The ease of speaking through an avatar compared to face-to-face is not as great as the difference in engagement, but still visibly improved as can be seen in the right graph in Figure 6.11.

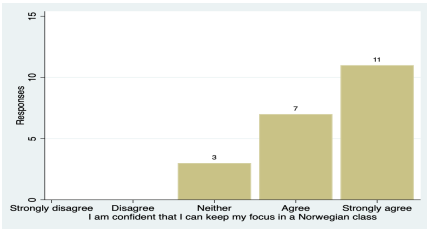
Comparing the participants from Lukas vgs to the ones from NTNU on comfort speaking through the avatar with the Wilcoxon rank-sum test we found a significant difference



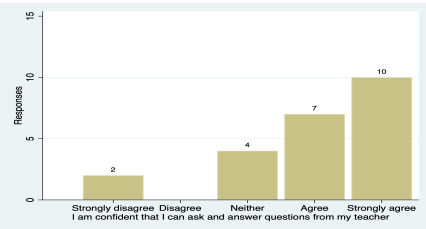
(a) I am confident that I can quickly learn the basics of a new technology.



(b) I am confident that I can hold a short conversation with another person in Norwegian.

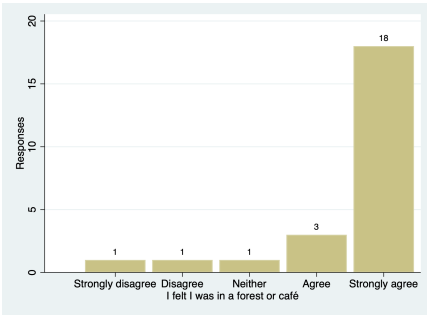


(c) I am confident that I can keep my focus in a Norwegian class.



(d) I am confident that I can ask and answer questions from my teacher.

Figure 6.9: Results from the self efficacy questions asked in the pre-test questionnaire.



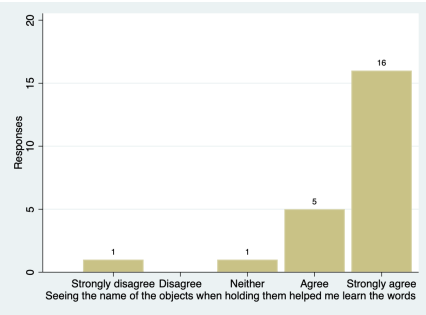


Figure 6.10: Results from the first two questions from the post-test questionnaire. If they felt they were in a forest/café (left) and if seeing the name of the objects helped them (right).

($p = 0.005$) which can also clearly be seen when comparing the two results, Figure 6.12, where participants from Lukas had a more drastic improvement in comfort when it came to speaking through their avatar with 73% agreeing.

The open questions were, in the same way as described in the pre-test questionnaires, coded and the most notable results will be presented here. When asked what they thought of the virtual environment there was an overwhelming response of positivity: mentioning it was fun and exciting, realistic and made learning easier. The complete coded results can be seen in Table 6.5, 22 of the 25 participants answered this question and the responses might fit into more than one category.

When asked how being in a different environment affected their learning experience,

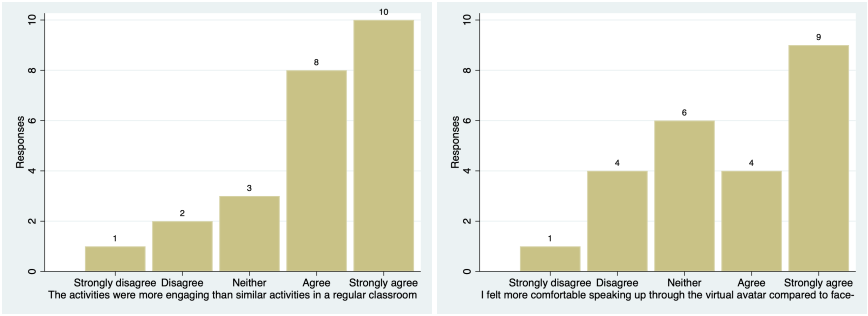


Figure 6.11: Results from questions comparing engagement (left) and comfort in speaking (right) in VR and a regular classroom.

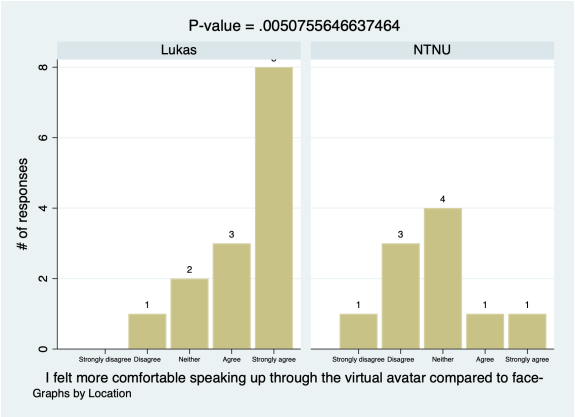


Figure 6.12: Comparison of participants from Lukas vgs and NTNU of comfort in speaking through an avatar.

What did you think of the virtual environment?	Responses
Interesting and exiting	7
Realistic	5
Interacting with objects made learning easier	4
Nice setting	4
Liked speaking to other people in another location	3
Enjoyable	3
Many possibilities	1
Blocks out distractions in the real world	1
No added value	1

Table 6.5: Coded responses to the question “What did you think of the virtual environment?” from post-test questionnaire (21 responses).

people answered that they had a good time (it was more fun), there was a stronger association between a word, its appearance, and use, and there was a better sense of fellowship. The full results, coded, can be seen in Table 6.6. 19 participants answered this question, and the responses could fit into more than one category.

How did being in a different environment affect your learning experience?	Responses
Stronger association between a word, its appearance and use	6
More fun	5
Group feeling	3
Took some getting used to	3
Good experience	3
Interactive	2
Negatively	1
Uncomfortable and warm	1
Closer to a real situation	1
Paid more attention	1

Table 6.6: Coded responses to the question "How did being in a different environment affect your learning experience?" from the post-test questionnaire (19 responses).

Two of the questions asked: what, in their opinion, the three best and worst aspects of the application was. Fun was an occurring answer yet again on the best aspects, only beaten by interaction with people which was mentioned by 12 of the 22 who answered the question. When asked to name the worst aspects only 17 people answered. Six of them felt it was difficult to use the application while two respondents called it time consuming. There were several responses related to hardware issues or the headset being uncomfortable which we had no control over, and some limitations in the application which was there by design (i.e not being able to walk far into the forest and spawn every objects like the teacher could). Some bugs and glitches were mentioned as bad, these will be answered in Section 8.3. The complete coded results from both these questions can be seen in Table 6.7 and Table 6.8.

We wanted to figure out what the students' thoughts were on interacting with a teacher in VR. The results show it was more equal and engaging, the full coded results from the 19 responses can be seen in Table 6.9.

Finally, we asked what advantages a VR classroom had over a regular classroom and vice versa. The coded results from 18 and 16 responses respectively, can be seen in Table 6.11 and Table 6.10. Many compare the VR classroom to a game, describing it as more playful. There are several other advantages we made note of, such as users could be anywhere in the world and still appear to be right next to each other, and the environment and scenario they are together in could be anything. People felt that these scenarios to be simulated in the VR classroom were more genuine compared to a regular classroom. Though not everything was perfect, as some mentioned: a regular classroom is much easier to use because of past experiences. One has also in a regular classroom: the ability to actually touch physical things as well as taking notes, which was also mentioned as one of the worst aspects of the application in Table 6.8. The response also mentions a regular classroom scales better in both directions: it works better for large groups/classes and for

What would you say is the BEST aspects of the application?	Responses
Interaction with people	12
Fun	9
Support for new vocabulary	8
Freedom	5
Different	4
Easy	4
Getting help from the dictionary and objects	4
Interactive	4
Exiting new technology	4
Collaboration	4
Realistic	3
Typically Norwegian	2
New	2
Engaging	1

Table 6.7: Coded responses to "What would you say is the best aspects of the application?" from the post-test questionnaire (22 responses).

What would you say is the WORST aspects of the application?	
Difficult to use (at first)	6
Hardware limitations	5
Limitations in application	4
Not comfortable wearing the headset	4
Bugs in application	3
Difficult to hear people far away	3
Voices from real world and VR at the same time (echo)	3
Time consuming	2
Not realistic	1
Cannot take notes	1
Distracting	1

Table 6.8: Coded responses to "What would you say is the worst aspects of the application?" from the post-test questionnaire (17 responses).

one-on-one interactions with the teacher.

Connections Between Questionnaires

Many of the questions in the pre- and post-test questionnaires were connected, the difference being in real life first and then in VR. This was done to compare feelings and self-efficacy in a traditional to a virtual classroom. We found no significant difference when comparing most questions. Table 6.12 shows what variables were compared and the p-value returned by the Wilcoxon matched-pairs signed-ranks test. As can be seen in the table, only the comparison of focus has a p-value less than the critical threshold of 0.1, meaning that is the only comparison with significant difference. The actual result from the

Interacting with the teacher in VR compared to a regular classroom?	Responses
More equal	7
More engaging/fun	5
Not shy	3
Worse	2
Similar	2
More personal	2
Less formal	2
Missing body language and facial expressions	1
Missing something to write on	1

Table 6.9: Coded responses to "What is your thoughts on interacting with the teacher in the virtual space compared to a regular classroom?" from post-test questionnaire (19 responses).

Advantages in a VR classroom compared to a regular classroom?	Responses
More playful/practically oriented	7
Not bound geographically	4
Any setting/situation	3
More social	3
More accessible tools	2
More realistic settings/situations	2
No consequences to actions	1
Less dependent on teacher	1
Sense of anonymity	1
No advantages	1

Table 6.10: Coded responses to "What advantages does a virtual reality classroom have compared to a regular classroom?" from the post-test questionnaire (18 responses).

Advantages in a regular classroom compared to a VR classroom?	
Easier (more used to)	4
Can take notes	3
Physical	3
Supports more people	2
Seeing real people is nice (more personal)	2
Better for complex tasks (e.g grammar)	2
Access to curriculum	2
One-on-one interaction	1
Teacher has more control	1

Table 6.11: Coded responses to "What advantages does a regular classroom have compared to a virtual reality classroom?" from the post-test questionnaire (16 responses).

participants' confidence in keeping their focus can be seen in Figure 6.13, and show that students are more confident in their ability to keep focus in a regular class over a virtual class, with almost double the number of strongly agreeing responses.

First variable	Second variable	p-value
I am comfortable speaking to the teacher in front of the class	I felt stressed when talking to the teacher in front of the class in VR (inversed)	.385
I don't mind making mistakes when speaking Norwegian. It does not bother me	I felt embarrassed when I made a mistake	.320
I don't feel any shame after making a linguistic error	I felt embarrassed when I made a mistake	.247
I am confident that I can hold a short conversation with another person in Norwegian	I am confident that I can hold a conversation in Norwegian with another person who is using a virtual avatar	.644
I am confident that I can keep my focus in a Norwegian class	I am confident that I can keep my focus on the Norwegian course while using the application	.083
I am confident that I can ask and answer questions from my teacher	I am confident that I can ask and answer questions from my teacher in virtual reality	.374

Table 6.12: Different pairs of pre- and post-test questions, compared using Wilcoxon matched-pairs signed-ranks test.

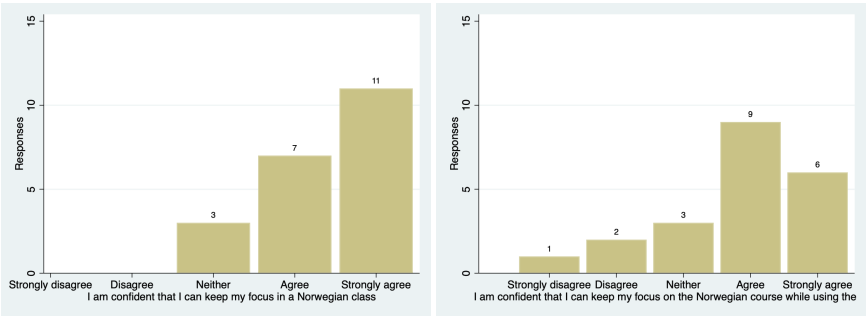


Figure 6.13: Result of confidence in keeping focus in a regular classroom (left) and in a VR classroom (right).

6.3.2 Interview Results

The interviews were done a couple of days after the final evaluation. We prepared an interview guide which was executed in a semi-structured fashion. This meant we had

themes we wanted to cover and some questions, but were also willing to add new questions if it felt natural to the "flow" of the conversation [8]. One held the conversation and asked the questions, while another would write down notes about what was said and participated if necessary. The interview was also recorded with a dictaphone not connected to the internet, following the rules of GDPR [9]. This recording was then transcribed and used further for qualitative analysis. Participants were also aware of the process and signed a consent form which can be seen in Appendix A.1.

6.3.3 Interview Data Analysis Process

We followed a similar process to analyse the interview as the one explained by Oates [8]. The data was first prepared by transcribing the interviews and sorting them by which interview they were from and what questions they answered. These were then read in several iterations to find central themes that were found in all the answers. The themes are defined by either similarities among the answers, relation to research questions or just important topics. In the following sections, we will present situations or comments where we will refer to a specific teacher. This will be done using an ID which is shown together with some background information in Table 6.13.

ID	Location	Has tried VR before?	Performed VR session with	VR Session
A	NTNU Trondheim	No	International students from NTNU Trondheim and Gjøvik	1
B	NTNU Trondheim	No	International students from NTNU Trondheim and Gjøvik	2
C	Lukas vgs	No	Minority students from Lukas vgs	3
D	Lukas vgs	Yes	Minority students from Lukas vgs	4

Table 6.13: A summary of the teachers who participated both in the VR sessions and interviews.

As previously mentioned, there were a difference between the VR sessions. The participants from VR session 1 had a higher Norwegian language proficiency in general than the participants from VR session 2. Except the participants from Gjøvik in session 1, who were at a lower level than the rest of the group in Trondheim. The students from Lukas vgs in VR session 3 and 4 were mostly at the same level.

6.3.4 Interview Results

We have found five themes in the interviews that has been used to organise what was said. The following sections presents the results from each theme.

Teacher's Role

This theme is centred around the teacher's role with the sub themes: teacher's concerns, spontaneity and flexibility, and potential.

Three of our four participants, those who had no experience with VR, shared a certain curiosity. They had questions about how it could be used, if it could actually work for teaching and how different it would be. There were questions about dynamics changing between teacher and students, if communication between them would change and how it would change if it did.

Spontaneity and flexibility is in terms of how much the application would allow them to respond to changes and enabling creativity. Which they found out later was easier than they anticipated and felt that they wanted to be more spontaneous towards the end of the VR session. This spark of spontaneity could be connected to the fact that this was the first time they had used it with the students and seeing it used as intended. It was speculated that this is because it is easier to see the possibilities when one is in such a situation, not before. While teacher D, one who had more experience with VR, meant that VR has an ability that urges you to become more spontaneous.

Lastly, potential is in relation to the potential of VR as a tool for language teaching. All of them said that this potential was something they could see more clearly after the VR session. Once again, this can be related to the comment about having to experience it to see the possibilities. This is also closely related to several other themes that address their experience in the VR session such as "Communication" and "Teaching in VR". Teacher D had a comment which is directly related to the teacher's role. They mention that a teacher might not be an instructor in such an environment, but more of a facilitator that lets their students explore on their own. This coincides with the theory by Kolb [31] mentioned in Section 2.3.3.

Communication

One of the main elements of the application is collaboration which has communication as one of its' main components, as we mention in Section 2.1.5. Under this theme is: sound, interaction with students and body language.

Sound relates to one of our features, spatial audio, which is mentioned in Section 5.5.3 and Section 5.6.2. Three out of four participants mentioned that the sound worked quite well and that having a conversation in VR was surprisingly similar to real life. However, teacher C had a slight disturbance because they could hear the voices of people in real life and in VR after a slight delay. This is because of how the physical space of the VR lab is constructed. The booths where the VR stations are situated are right next to each other and not completely closed off. Unfortunately, this caused confusion about who was talking and where the attention of the teacher should be.

Though most of the teachers expressed their content with the sound and holding a conversation, they also felt that there was an important missing quality in VR: being able to read body language. Something they learned was how to communicate with the limited way you can express yourself by waving your hand or pointing. However, they felt that they lost an ability to interpret students and to communicate certain feelings. For example, teacher B had to explicitly say to their students that they were smiling to set the mood. Another factor was maintaining eye contact which they felt was important when talking

with others. This became especially difficult when, during VR session 1, a student was having problems with the controls. The teacher tried to help, but was not capable of seeing how the student reacted to their assistance. The body language of the virtual avatar could not properly show frustration even though they heard it through the voice chat. In addition to this, the student that was having problems was located in Gjøvik while the teacher was in Trondheim which made the situation even more complicated.

Despite the limitations of the virtual avatar, all the teachers mentioned that the interaction with students was positive. One of the teachers said that there were some differences, but much less than expected. It was also noticed that the students were having fun and were more playful even when they were doing "simple" assignments. Teacher C and D, who performed the VR sessions with minority students, experienced that there was a flatter hierarchy between teacher and students. That the presence of the teacher was less noticeable and the teacher lost their "leader" role. A specific moment was mentioned where a student had picked up an object in the environment and started hitting them with it. When the student had found out that they were hitting a teacher, they became shocked. The teacher was quite surprised by this behaviour, as they felt that the students were usually more constrained and respectful in the classroom. The teachers expresses this flatter hierarchy as both positive and negative. Positive, because students become more expressive and can enjoy learning, but negative because it becomes more difficult to control them. On the other hand, teacher A did not feel that there was a noticeable difference in the dynamic between them and their students. In fact, they felt that it was quite similar as to what it was in a real classroom, but also comments that this might vary on the type of students.

Teaching in VR

This theme will address the teacher's experience with teaching in the VR session with two sub themes: planning the VR session and difference in skill level among students.

The teachers had different approaches when they had the VR session. Teacher A and B had planned together and had a specific idea in mind, while teachers C and D had a more improvised session that was based on a theme. They point out that preposition assignments was the most obvious choice. However, both teacher A and B said it was rather limited, or even difficult, to create assignments because the application had several constraints. They wished for more objects in the environment and the ability to do more with objects: make the objects interact with each other. It was also speculated that the lack of experience with the environment and the application could be a reason to why it was difficult. Despite this, they also felt that going through the assignments with the students went well, especially considering the students were not given any instructions beforehand.

With the teachers at Lukas vgs, they went for a more improvised session because of preferences and also a lack of time for preparation. Teacher C felt stressed at the beginning, but became more comfortable as time went on. Once again it was mentioned that it would have been easier if they were more familiar with the environment. Teacher D, on the other hand, said that this was how they preferred to teach. Furthermore, they felt that VR was natural for spontaneous situations and that it is difficult to plan these natural situations.

The teachers had a positive experience with the students they already knew, but felt it was difficult with students they had not met before. These insights were from the teachers at NTNU who had students from Gjøvik. As mentioned previously in the "Communica-

tion" theme, there was a situation where one of the students from Gjøvik had difficulties with the controls. This problem caused frustration for both the teacher and the student, but also in general it was difficult for the teacher to relate with the students they knew nothing about.

Also, a difference in skill level between students was an important factor to consider when designing or holding a lesson which was the case in VR session 1. In VR session 2 the situation was the same, but the students were at a more similar level. Despite this, teacher B still had the same opinions. This was because to them they were strangers and more importantly they did not know how proficient they already were with the language. They mention that it would be useful in the future to have a way to see this kind of information and enable teachers to group students at the same level before jumping into the VR session.

Virtual Environment

The virtual environment was a theme that was mentioned several times during the interviews which is also connected to presence.

All of the teachers were happy with the virtual environments, either because of the atmosphere, how it is designed or that it was interesting. The forest was seen as relaxing and comfortable to be in, while the café was mentioned as being big and having several areas that felt natural to rally around in. Teacher D also observed that the students seemed to feel more at home at the café and says that it might be because of familiarity. However, it also seemed that this was a matter of preference for the teacher as most of them appreciated having several environments to choose from. In a more general case, they appreciated having a lot of objects and areas which could start conversations. It was also mentioned that it felt like everyone was in the same place which is the feeling of place-presence and co-presence mentioned in Section 2.1.4. An advantage that was also seen is that pictures are often used in classrooms, but with the application one could go around the environments and touch these objects. This difference was seen as both useful and maybe one of the greatest differences to a regular classroom.

Technical Issues

The last theme is technical issues with its sub themes: VR application weaknesses and new functionality.

The teachers have already mentioned several weaknesses with the VR application, like a lack of human expressions such as body language and eye contact. But, there was also an issue of getting used to the controls. All of the teachers said that the controls were easy and intuitive, but that they needed time with it. The tutorial was also not enough on its own as we had to assist them when they were learning the controls. This was also an issue that was observed with the students.

In the interview, they also asked about improvements or features that they wished to see if further development was to be done. The first thing that almost everyone mentioned was a more complex way of interacting with the objects and the environment. What they meant with this, was enabling objects to interact with each other, e.g that a knife can cut an apple in two or putting objects inside a backpack. Also, that the avatar can interact more

with the environment, the teachers noticed that several students tried to sit down on a chair only to be disappointed.

The next features to be mentioned were about adding new abilities to the teacher mode. The first feature that was mentioned in almost every interview was the ability to write notes and have a blackboard or similar. The teachers wanted a way to show the goals for the session. This is similar to showing "today's goals" during a normal classroom lesson which we observed in the problem definition process explained in Section 4.2. By having this feature it was also possible to ease giving instructions, seeing as some had problems controlling bigger groups on their own, especially when they had to repeat instructions. There was another feature that was seen as a solution, but also just useful to have on its own: to give the teacher an ability to turn off spatial audio on themselves. By doing this, the teacher would be able to give a message to all the students no matter where they were. There was also a suggestion that might counteract the worry about the flatter hierarchy between teachers and students, that was brought up in the "Communication" theme. Which was to give the teacher's virtual avatar a different and more noticeable look. For example, a bigger avatar or give them a commanding presence.

One of the teachers also wanted to change how you could add new objects. At the moment, it is only possible to add objects one by one either by first scrolling to find the object and then pressing the "add object" button or voice recognition button. This was found to be cumbersome and they wanted to have a way to add several objects at once. Lastly, they wanted objects that were minimal pairs to use them when making assignments, e.g bus/buzz and fan/van.

Chapter 7

Discussion

This chapter will discuss the findings and limitations found during the project.

7.1 Discussion About Findings

The findings show that there is great potential for using VR in Norwegian language teaching and learning for adult immigrants with at least secondary education. There were increased motivation among students, the social interaction was found to be more engaging and fun, the sense of presence was strong and, in some cases, students were more comfortable speaking to the teacher. The teacher's role points toward that of a facilitator: collaborating with the students together in the virtual space. Furthermore, as the sessions went on, the teachers were inclined to be more spontaneous. Constant feedback from the user group were necessary to develop the application, therefore an agile framework and user-centred design were used. During development, a challenge was found when balancing resources between implementation and user testing. A choice of prioritising the development was made, but we cannot say with certainty if it was optimal.

Overall, there is a positive outlook on the use of VR for Norwegian language teaching. 70% to 74% of the participants said they believe in the technology in this context, while only 4% to 8% did not. Molka-Danielsen and Deutschmann [20] explains attitudes towards VR reflects the motivation to use it, and in turn, affect the experience had; this became apparent with one participant, whose attitude was reflected in their lack of engagement and comments received after the session, like "I don't really believe in VR". On the other hand, this could also explain all the positive answers after the test, as most expressed positive attitudes going in to the evaluation. The teachers had no VR experience, with one exception who had positive experiences using VR, and were at first driven by their curiosity towards the use of this technology in their domain. This was their primary motivation to be engaged in and be a part of this project. Throughout the project, the teachers' attitudes towards the application's potential became more positive. Especially

after the final evaluation where they got to simulate a real use-case, as said in the teacher interviews in Section 6.3.2.

7.1.1 Social Engagement

The social aspect of the application, of meeting other people and interacting with them, has been mentioned several times: in the questionnaires, interviews and general feedback from various events. With 75% agreeing to the VR class being more engaging than a regular class, which was also perceived by the teachers when they commented that students were more playful when doing "simple" assignments. This supports other findings of VR promoting learner engagement [3]. The increase in engagement, in addition to the positive self-efficacy results, is an indication of an improvement in motivation. These results backs the findings on motivation done by Wehner, Gump, and Downey [7]. Despite this, measuring motivation is difficult, as we mention in Section 2.3.4, and we cannot properly conclude if the application increased motivation.

This engagement is supported by a strong feeling of immersion, or more specifically place-presence, co-presence and social-presence, as explained in Section 2.1.3 and Section 2.1.4. Place- and co-presence are important factors for proximity, which is a component for collaboration together with awareness and communication. 87% of participants said they felt like they were in the given environment, showing strong place-presence in the application. The interviews also points towards a sense of co-presence, as the teachers felt everyone was in the same virtual room regardless of their geographical location. With regards to social-presence, when asked what their favourite aspects of the application was, 12 of the 22 respondents mentioned interaction with people. Again, this is an important element as it could be connected to satisfaction [15]. This strong feeling of immersion can lead to positive learning outcome as the findings shown by Legault et al. [57]. But as this was not part of the evaluation, we could not assess the learning outcome as we will elaborate in Section 7.2.

7.1.2 Relationship Between Teacher and Students

Our application was partly inspired by social-constructivism, which presents the importance of social interaction with the teacher and other students in education, as mentioned in Section 2.3.2. The theory also highlights the significance of collaboration between the teacher and students. This, together with the observations done during the evaluation sessions, points to the teacher's role being that of a facilitator: one who creates task-based instructions, and guides and engages students to interact with one another. Meaning that the teacher should have an active part in the virtual environment. Pishghadam and Mirzaee [29] and the teacher interviews further support this view.

In some cases, depending on the existing relationship, the hierarchy between the teacher and students were found to be flatter: the students found it more comfortable to speak to the teacher. 73% of the Lukas vgs participants agreed to being more comfortable speaking to the teacher in VR, with no participants strongly disagreeing. NTNU participants on the other hand were indifferent (with a p-value of 0.005). From one of the interviews we learned that the immigrant students at Lukas vgs had more respect for their teachers

compared to local students. The students from NTNU on the other hand had a much closer relationship with both each other and the teacher, as well as being more confident speaking up in general; there was no noticeable difference. An explanation might be that the anonymity of the virtual avatar gave them the courage to speak up. Though, a negative side effect brought up by a teacher was: while students became more open and engaged, they also became more difficult to control. The questionnaire further strengthens this as the students found it more challenging to stay focused in the VR session.

An explanation for the equality in hierarchy between teachers and students could be the virtual avatar. In short, the avatar was designed to be gender-neutral and to avoid the uncanny valley, details of the design can be found in Section 5.5.2. As explained in Section 2.1.6, the virtual avatar can create a new identity for users where they can be more open for new knowledge and social constructs. Unfortunately, the avatar lacked expressive body language and proper eye contact, as well as limited customisation options. This created a negative effect on immersion and social interaction which was mentioned in the interviews.

7.1.3 Design and Development

For development, there were several reasons for choosing user-centred design: improving usability, getting pedagogical feedback from experts and get insight into how to support social interaction in VR. Improving usability is the primary goal of user-centred design through iterations which fits the chosen development method, Scrum. We tried to compensate our lack of pedagogy background by including experts in the form of language teachers during development. At the same time, this was an attempt to answer the research gap regarding the inclusion of the teacher in VR applications made apparent by Lin and Lan [3]. Once again, since the application draws influence from social-constructivism, we wanted to get an understanding on how users would interact with each other. Having continuous conversations with our user group made this possible. But, we cannot say for certain if this was the optimal way to do so, as we have nothing to compare to.

When designing the application, we also took inspiration from Kiili's experiential gaming model, described in Section 2.3.3. This is apparent when given the process of students facing challenges, creating solutions and reflecting over what has been done, with the goal of creating "flow". We observed this state of "flow" during evaluations, as both the students and teachers were immersed in the activities and lost track of time. We see this as a great success, to the extent of it being so effective that the teachers requested a clock in the virtual space such that they could better keep track of time.

7.2 Limitations

There were several limitations that could have affected the results. As mentioned during this thesis, VR technology is still in an early phase and still has some issues i.e tracking issues, the HMD being uncomfortable and users not used to the interface of VR. There were also limits to other resources such as time and money. These resource limitations, in addition to our lack of experience with 3D-modelling, meant we had to take some

shortcuts on the application, like access to the interactable objects we wanted and sub-optimal models of the ones we found. The lack of time also meant some features were incomplete or not added at all. In addition to the aforementioned resources, we also had a limited access to end-users. We would optimally had more participants during all tests, both teachers and students, and more time with the participants we had. We could therefore not perform proper long-running tests to see if there were any learning outcomes or have a control group, as is usual in language learning studies [46] [57], and had to limit the overall scope.

We are both students of informatics and had no experiences with pedagogy prior to starting this project. This caused us to not be able to properly use pedagogical theory and concepts and had to rely only on surface level and conversations with experts. This has most likely resulted in a large gap of research that is fatal for an application like this, as will be elaborated in Section 8.3.

When designing the final evaluation, we gave the teachers freedom to create the Norwegian teaching session to be used, as we did not know the pedagogy behind doing so. The four teachers participating were located at different sites and did not have a lot of time to meet up. The session was then designed by two of the teachers and summarised to the other two short time before the final evaluation. This was apparent in the actual evaluation when they, in addition to their own teaching preferences, held different variations of the session planned. They said it actually represented how an actual class would be: with a main plan, but spontaneous and improvised on the spot. But, in an evaluation sense, this could give different results from the participants experiencing different Norwegian classes. There were also differences between the evaluations with NTNU participants and Lukas vgs participants, where the NTNU evaluation was performed with one group each day. While with Lukas vgs, it was less structured and was done with two main groups right after each other. The Lukas vgs evaluation also had a bit of overlap between the groups and a few participants jumping in and out of the VR session, this further influenced the teachers' choice to keep the session more unstructured. Given this, every participants got to experience the application and its use in a language learning class, but the experiences themselves were most likely different.

Another difference between the evaluation conducted at Lukas vgs and NTNU, was the hardware. The students that was located at Lukas vgs during the test did not have access to the HTC Vive, but had their own Oculus Rift setups. This affected their experience, as some students had to drop out early after feeling dizzy or nauseous. Cheng, Yang, and Andersen [52] found similar results when they tested with the Oculus Rift as well, specifically recommending the HTC Vive instead. Even knowing this, we had no other choice as it was the only available option at the time.

Half of the questionnaires were in English (NTNU) while the other half were translated to Norwegian (Lukas vgs). We did as best as we could to have an accurate translation, but some details might have been lost in translation. Some questions themselves might have also been interpreted differently between participants, again we tried to avoid this by making questions as explicit as possible.

The development was divided into implementation and testing. Both of these were crucial and required a lot of resources. Unfortunately, with our limited resources, we chose to simplify the user tests while trying to keep the integrity of the results. This was

done by having the user tests without having an actual language lesson with both a teacher and students, and rather give the intended context orally. We are not certain if this was enough to accurately reflect an actual use case for the application, but the positive results from the final evaluation shows that it might be authentic enough. However, we do not know how more thorough user tests would have affected the end results, seeing as this would have shifted resources from implementation.

Taking notes at the same time as holding a demo at the conferences was difficult, which meant that the observations made at the time was not properly documented. This might have weakened the dependability of our findings, as one is not able to get the full details and have to trust our own depiction of the events.

Chapter 8

Conclusion

This chapter will conclude the thesis with answers to the previously stated research questions, our research contributions and suggestions future work.

8.1 Research Questions

This section will answer all the research questions, as well as their their sub-questions, asked in Section 1.4.

8.1.1 RQ1

Answers to research question RQ1: ”How can a collaborative Virtual Reality application support the language learning of adult immigrants with at least secondary education in Norway?” and its sub-questions.

RQ1.1: What challenges are there in Norwegian language learning for immigrants with at least secondary education in Norway?

We performed observations, surveys and interviews with immigrant students and Norwegian teachers as described in Chapter 4. These results were summarised as user needs in Table 4.4. There were two main areas with challenges: the first was in the classroom, where the students struggles with both pronunciation and vocabulary. Secondary, is outside the classroom, where the language to be learned is not used and practice is fundamental when learning a new language. Finally, covering both areas, is the need for motivation to learn.

RQ1.2 How does the context of the virtual environment setting influence language learning?

Both the forest and café environment showed a high degree of presence and increase of motivation. When comparing the results from both groups, there were no significant difference. The interviews with the teachers showed enthusiasm for both environments with different preferences. These preferences also support the claim that pedagogy today is heavily controlled by the teacher's experience and expertise [29] [28]. They all agreed that having more options is the way to go, and is one thing VR can contribute to education. Many students who tried both also uttered preferences to one environment or the other.

RQ1.3 To what extent does a Virtual Reality application influence the user's motivation towards language learning?

Improvement in learning engagement was observed and the positive self-efficacy results points towards an increase in motivation. Three influencing factors are: a strong feeling of presence, the social interaction with other people in the virtual environment and the attitudes towards the use of VR.

RQ1: How can a collaborative Virtual Reality application support the language learning of adult immigrants with at least secondary education in Norway?

A collaborative VR application can answer the challenges found via RQ1.1, by giving a platform to speak Norwegian with peers on while helping the users learn new vocabulary and its pronunciation. The specific environment in which the virtual sessions are held, does not show any immediate significance. Other than the teachers' preference in teaching style and demand for variation. This type of application seems to increase the users' motivation towards language learning, but we cannot answer this with certainty.

8.1.2 RQ2

Answers to research question RQ2: "What is the relationship between the teacher and students when using virtual avatars in a VR Language Learning application?" and its subquestions.

RQ2.1 What is the teacher's role in such a VR application?

The teacher's role in such a VR application is more suited to that of a facilitator, highlighting the collaboration between the teacher and their students. Following the theory of social-constructivism.

RQ2.2 How does having a virtual avatar influence the social interaction between people in such a VR application?

We found two different outcomes in relation to the interaction using an avatar. The first being no apparent difference; the social interaction was similar to face-to-face interaction in a regular classroom. Secondly, we also found some users feeling more comfortable speaking up through a virtual avatar. Regardless, having this simplified representation of

oneself meant missing the intricate details of communications, such as expressive body language and proper eye contact.

RQ2: What is the relationship between the teacher and students when using virtual avatars in a VR Language Learning application?
The relationship between people using avatars in a VR application is similar to the real world. The virtual avatar grants a certain equal standing between users, most noticeably between the teacher and student. If people were afraid to speak up, the anonymity of the avatar encouraged them to do so. On the other hand, if they already were comfortable in speaking up, no change was observed. Some negative consequences were the lack of communicative details and more difficulty with staying focused.

8.1.3 RQ3

Answers to research question RQ3: ”How can one develop an immersive and collaborative VR application for Norwegian language learning?” and its sub-questions.

RQ3.1 What requirements would such an application need to answer the challenges faced in Norwegian language teaching for immigrants with at least secondary education in Norway?
RQ1.1 resulted in several challenges, some of which resulted in a list of user needs, listed in Section 4.4.1. The specific requirements set to answer these were defined by continuously talking with the end-users and can be seen in Section 4.4.2.

RQ3.2 How can one implement a VR application answering these requirements?
This was done using an agile development method and user-centred design to meet the requirements found in RQ3.1. This is thoroughly explained in Chapter 5. The design of the application was also inspired by the social-constructivism theory and Kiili’s experiential gaming model, as explained in Section 2.3.

RQ3: How can one develop an immersive and collaborative VR application for Norwegian language learning?
We defined what requirements the application should have by looking at the results from RQ1.1 and refined them continuously within our development with close conversations with end-users. This whole process and the detailed results can be seen in Section 4.4 and Chapter 5. Though we have not compared this to any other method and cannot conclude if this was the most optimal solution.

8.2 Contributions

As a result of this project, we have several contributions. We developed a collaborative VR application to be used in Norwegian language teaching. The application was used to

get insight into the teacher's role, the relationship between students and the teacher and the potential of using such an application in language learning classes. We also got a better understanding of the potential of distributed collaboration and how presence affects motivation. The development is also documented and a list of challenges in Norwegian language learning has been found. The contributions are presented in the following list:

- A collaborative VR application for Norwegian language teaching (Chapter 5).
- Insight into developing a VR for Norwegian language teaching application using user-centred design (Chapter 5).
- Insight into the the teacher's role in a collaborative VR language teaching application (Chapter 7).
- Insight into the social relationship between students and teachers in VR (Chapter 7).
- Better understanding of the potential of distributed VR collaboration (Chapter 7).
- Better understanding of how presence felt in VR affects motivation (Chapter 7).
- Insight into the potential of using VR in Language learning classes (Chapter 7).
- A list of challenges today in Norwegian language learning and teaching (Chapter 4).

8.3 Future Work

Looking forward, there are several areas that can be improved upon or delve into deeper. These areas are also our suggestions to what can be worked on and are gathered from our experience and findings.

We can first mention the technical bugs and challenges that was discovered during the project. Most of them have already been discussed in Section 5.6. To summarise: the animation of the hands is not synchronised, the colour of objects will at times not be synchronised properly and the microphone will not be detected if it is activated after the application starts. Some bugs do not have an obvious relation to the previously mentioned. For example, most of the time if one exits a room and re-enters, the left hand becomes inverted which gives it a broken appearance.

Even though there is great potential here, one thing we will make note of is the difficulty of measuring learning outcome. With the short evaluation period that we performed, it was not possible to properly gauge how much the students were learning from the VR sessions. Furthermore, as we have already mentioned in Section 2.3.5, we do not have background in pedagogy and therefore do not have the full confidence to perform such a test. Therefore, we recommend a much thorough, focused and longer testing period to see if the application truly gives positive learning outcome.

The response we received from the teachers, mentioned in 6.3.2, also show issues with the virtual avatar. They list several drawbacks such as: lack of eye contact and almost no way to communicate body language. In addition to both of these, there is no customisation option other than choosing a colour for the avatar. Answering these concerns will improve

immersion as it is a closer simulation of reality. It can also improve collaboration since these are subtle ways of communication, for example to express frustration, understanding and satisfaction. More customisation options will give them the ability to better represent themselves and allow them to take new identities in the virtual world to better fulfil the benefits mentioned by Molka-Danielsen and Deutschmann [20] and Wehner, Gump, and Downey [7].

Adding more environments and objects is another suggestion from the teachers. This would aid them in creating content for students and encourage them to become more spontaneous. Additionally, having interactions between objects will give more freedom and possibilities to what can be done in the application. This was mentioned in the interviews and that it was not possible could break immersion.

Because there was no clear affordance and a lack of signifiers with the menu interaction and navigation around the environment, we created a tutorial to counterbalance this. However, we observed that the tutorial was not enough. This is a result of not enough testing with the tutorial, and we therefore recommend to work further with the design of the tutorial or a more visible way to show the controls.

Lastly, there was another potential challenge that was not entirely in our scope, but still relevant for future users, is the topic of universal design. When starting our study, we had a focus on immigrants with at least secondary education in Norway, but there were factors we chose not to include. For example, we did not design the application to suit the needs of one with disabilities. Despite this, the visit from Statped, which is discussed in Section 6.1.3, indicate that there is great potential in using the application to support students with special needs. A suggestion would be to see what types of disabilities VR can cover and to include this user group, a focus on the principles of universal design will be necessary. Even something so simple as checking if students with different educational background have the same results should be considered.

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Appendix A

Appendix

Taking part in the research project

”Immersive Technologies for Learning and Training”

This is an inquiry about participation in a research project where the main purpose is to to explore the potentials and limitations of Immersive Technologies (virtual/mixed/augmented reality, VR/MR/AR) for learning and training in different areas, as a part of master student projects at Innovative Technologies for Learning (IMTEL) VR lab. To conduct this research, we will need to investigate the development and use of immersive technologies for learning and training in various contexts, including learning of language and mathematics, visualization of climate change, immersive exploration of historical manuscripts, workplace training and visualization of medical procedures. In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project
To conduct this research, we will need to analyze the use immersive technologies for learning and training in various contexts, including learning of language and mathematics, visualization of climate change, immersive exploration of historical manuscripts, workplace training and visualization of medical procedures. The goal is to develop innovative learning methods and tools using immersive technologies.

Who is responsible for the research project?
NTNU, Department of Education and Lifelong learning is the institution responsible for the project.

Why are you being asked to participate?
You are asked to participate because you are a potential user of educational applications developed as a part of this project and have visited our lab/expressed interest in immersive technologies. Your feedback is important for develop innovative learning methods and tools.

What does participation involve for you?
You will be ask to test immersive applications for learning and training purposes and then give feedbacks in the form of questionnaires and interviews/group interviews.

Participation is voluntary
Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data
We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act). Any data that can be traced to individual participants will be kept confidential and anonymized before being used for research purposes. Parts of the sound recordings will be transcribed (written down) and stored electronically. All source data will be handled and stored in accordance with the existing regulations by NTNU as the responsible institution and only persons associated with the project (IMTEL VR lab research personnel and master students) will have access to them.

What will happen to your personal data at the end of the research project?
The project is scheduled to end 31.12.2019. All data will be anonymized at the end of the project, e.g. audio and video will be deleted when transcripts and analysis of data are completed, except for selected video and photo material to be used for research purpose. These and anonymized recordings from the inside of the virtual environments may be used for demonstrations in research context in such a way that no information will be linked to individuals. Scientific reports and presentations from this study might contain recordings from the VR/MR/AR sessions, questionnaire results, anonymized photos/videos from the sessions and anonymized citations from the interviews.

Your rights
So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?
We will process your personal data based on your consent.

Based on an agreement with NTNU, NSD – The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?
If you have questions about the project, or want to exercise your rights, contact:

- Ekaterina Prasolova-Førland (Department of Education and Lifelong Learning, NTNU)
- phone: +47 99 44 08 61, email: ekaterip@ntnu.no
- NSD – The Norwegian Centre for Research Data AS, by email: (personverntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Consent form

I have received and understood information about the project **Immersive Technologies for Learning and Training** and have been given the opportunity to ask questions. I hereby declare my consent that my data in relation to Immersive Technologies for Learning and Training may be stored, documented and used for research and educational purposes as described above. I give consent for my personal data to be processed until the end date of the project, approx. 31.12.2019

(Signed by participant, date)

Both the priority-column and complexity-column has been set to either L (low), M (medium) and H (high) representing how important and complex each task is estimated to be. The time estimation-column is the stories' time estimation represented in number of man hours estimated to implement the given tasks.

ID	Description	Acceptance criteria	Priority	Complexity	Time Estimation (h)
US1	As a user, I want to have a comfortable environment so that I may feel safe	-An environment in a calm, dark forest with a campfire in the centre	H	M	30
US2	As a user I want to connect to other players so that we can play the game together	-Have a connection between players -The players are playing the same game in real time	H	M	45
US3	As a user I want an intuitive menu so that I can easily use the application	-Start the game with a menu -Be able to open a menu in game	M	M	30
US4	As a user I want the system to recognise words I speak so that I can get feedback on my pronunciation and be encouraged to speak Norwegian	-Be able to recognise the words on the cards -Give feedback	M	M	40
US5	As a user, I want a representation of myself, so that I can see and differentiate the different players	-Can see oneself and other players -The avatars must be different in some way -Avoid the uncanny valley -The avatar mimics the user's movements	H	M	20
US6	As a user I want to be able to communicate to the other players as if they were next to me so that I can have proper conversations	-Be able to send and receive voice chat across the users -Have spatial audio -Have a visual indicator on who is talking	H	H	150
US7	As a user I want to be able to interact with the world so that I can be more immersed	-Be able to pick up objects in the virtual world -Be able to move around the world (teleport)	H	L	30
US8	As a user I want to have background audio so that I feel more comfortable and immersed	-Have ambience audio playing in the background	L	L	10
US9	As a user, I want to collect Norwegian words and be able to see them in my personal dictionary	-Add the ability to collect words/objects -Have a separate collection for each player	H	M	15
US10	As a user I want to see the words of the objects I interact with and listen to the pronunciation of the words	-Make a simple way to add new assets -Model, animation and eventual sounds for each object	M	H	170

US11	As a teacher, I want to have more power and tools so that I can better control the learning sessions	-Add an admin mode setting -Add the ability to spawn any item -Add the ability to toggle invisibility	H	M	70
US12	As a user I want to be able to be able to select my own avatar so that I can to better represent myself	-A selection/customisation tool for the avatar	L	H	40
US13	As a user, I want different environments so that I can choose the environment most relevant for me	-Urban setting Find appropriate environment (cafe, pub etc.)	M	M	40
US14	As a user I want to see the words of the objects relevant to the environment I interact with and listen to the pronunciation of the words	-Model, animation and eventual sounds for each object in the new environment	H	M	60
US15	As a user I want to have a walkthrough of how to use the application before actually using it so that I can use the application without complications	-Create new tutorial scene -Create walkthrough of controls using text hints -Create individual tutorial for teacher and student	H	L	20

Table 1: A list of user stories in the project

Questionnaire VR in language learning

The purpose of this questionnaire is to gather data about language learning in relation to Virtual Reality (VR). We hope to gain a better understanding of both topics. The collected data will be used in our Master thesis, the use of VR in language teaching, and will remain anonymous. Thank you for participating!

Where are you from?

How long have you been learning Norwegian?

What are, in your opinion, the three biggest challenges in learning Norwegian?

1.
2.
3.

Before today, have you ever tried Virtual Reality?

- ▢ Yes
- ▢ No

Have you ever tried Virtual Reality in an educational setting?

- ▢ Yes
- ▢ No

(Page one of two)

Tick the box that matches your view most closely.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I believe that ICT (Information and Communication Technology) improves language learning.					
I believe that Virtual Reality can benefit learning.					
I believe that Virtual Reality can be used in learning languages.					

What do you believe works best as a VR language learning program?

- ▢ An AI using Voice recognition
- ▢ Conversing with another person

(Page two of two)

Interview Guide sprint 2

- Update about our progression
    1. What has been worked on since last time?
        - 3D spatial audio
        - Synchronization of objects
        - Menu
        - Voice recognition
        - Player avatar
- Try out the application
    1. Make a room named “Rom 1” and give yourself a username
        - The other person must then join the newly created room
    2. Inside the room, look at each other. What do you see?
    3. Take an apple and give it to each other
    4. Get closer to each other, say something. Go to each your own side of the forest, say something again

Question about the features

- Object synchronization:
    - How does it feel? Is it natural?
    - Should there be a bigger focus on this or is it good enough?
    - The hands, should we use more time on this or ignore it?
- Spatial audio:
    - Does it work well?
    - Any drawbacks? Should this be adjusted?
    - Is this good enough for recognizing differences between players or should some indicator be added?
- Player avatar:
    - Does the avatar look better?
    - Is the design going the right direction?
    - Mention other details that we’re thinking of adding (username, color)
- Menu
    - Does the menu look okay?
    - Any other buttons/options you/they would like to see?
- Voice recognition:
    - First impressions
    - How important is this feature for you?/Is this a feature you would consider to be important for the final product?

Questionnaire about VR in Language Learning

The purpose of this questionnaire is to gather data about our Virtual Reality application for use in language teaching. The collected data will be used in our Master thesis, the use of VR in language teaching, and will remain anonymous. Thank you for participating!

What country are you from?

What is your highest degree of education (pick one)?

- Primary School
- High School
- Bachelor Degree
- Master's Degree
- Doctorate Degree
- Other:_____

What language learning tools have you used, if any (e.g. Duolingo, Rosetta Stone, busuu)?

Have you tried Virtual Reality before today?

- Yes
- No

Have you tried Virtual Reality in an educational setting?

- Yes
- No

Tick the box that matches your view most closely.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
This application was easy to use.					
An application like this would motivate me to learn a new language.					
I would like to use an application like this in a language learning course.					
I would like to use an application like this outside the classroom.					

What was your favourite aspect of this application?

Do you have any ideas, be it either things you would change or add to the application?

Any additional comments?

ID:_____

Language VR pre-test

This questionnaire is part of a master thesis project at NTNU, Trondheim. The purpose is to gather data about the use of Virtual Reality when learning Norwegian. Afterwards, the information gathered will be analysed and used to support our research on this topic.
You will be given an id that will be used to connect this questionnaire to a follow-up questionnaire after the test. This ID cannot be used to identify you and will only be used to connect the two questionnaires. All data will be anonymous.

Background information

How old are you?

What is your gender? (Check one)

- ▢ Male
- ▢ Female
- ▢ Other

For how long have you been learning Norwegian? (Check one)

- ▢ Not at all
- ▢ Less than a month
- ▢ 1 - 6 months
- ▢ ½ - 1 year
- ▢ More than 1 year

Virtual Reality

Have you ever tried Virtual Reality before? (Check one)

- ▫ Yes
- ▫ No

If yes, which application(s) did you try out?

Tick the box that matches your view most closely

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I believe that Virtual Reality can benefit learning					
I believe that Virtual Reality can be used in teaching languages					

Why do/don't you believe that Virtual Reality can be used in teaching languages?

Language learning

Tick the box that matches your view most closely

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am comfortable speaking to the teacher in front of the class					
I don't mind making mistakes when speaking Norwegian. It does not bother me					
I don't feel any shame after making a linguistic error (using the wrong word, grammar, etc.)					

Confidence rating

Below are statements about certain abilities. Please tick the box that most closely relate to you.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am confident that I can quickly learn the basics of a new technology					
I am confident that I can hold a short conversation with another person in Norwegian					
I am confident that I can keep my focus in a Norwegian class					
I am confident that I can ask and answer questions from my teacher					

ID:_____

Post-test questionnaire

This questionnaire is part of a master thesis project at NTNU, Trondheim. The purpose is to gather data about the use of Virtual Reality when learning Norwegian. Afterwards, the information gathered will be analysed and used to support our research on this topic.
The ID given to you is used to connect this questionnaire with the questionnaire taken before the test. This ID cannot be used to identify you and will only be used to connect the two questionnaires. All data will be anonymous.

Virtual environment and objects

Tick the box that matches your view most closely

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I felt I was in a forest/café					
Seeing the name of the objects when holding them helped me learn the words					
Interacting with the objects made it easier to remember what they were					
I felt more engaged in the virtual environment compared to a traditional classroom					
It was easier to understand prepositions by placing and seeing objects in the environment					
I felt like I was in the same room as other people					

What did you think about the virtual environment?

How did being in a different environment affect your learning experience?

Language learning in Virtual Reality

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The application was easy to use					
Having a dictionary available at all times helped me remember Norwegian words					
Hearing the pronunciation of words helped me pronounce them myself					
The activities were more engaging than similar activities in a regular classroom					

I felt more comfortable speaking up through the virtual avatar compared to face-to-face					
I felt stressed when talking to the teacher in front of the class in VR					
I felt stressed when it was my turn looking for an object					
I felt embarrassed when I made a mistake (only answer if you felt you made a mistake)					

What would you say is the three BEST aspects of the application? (please try to answer all three)

What would you say is the three WORST aspects of the application? (please try to answer all three)

What is your thoughts on interacting with the teacher in the virtual space compared to a regular classroom?

What advantages does a virtual reality classroom have compared to a regular classroom?

What advantages does a regular classroom have compared to a virtual reality classroom?

Confidence rating

Below are statements about certain abilities in relation to the Virtual Reality application. Please answer how closely they relate to you.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am confident that I can get myself to use this application at least once a week as a supplement to a Norwegian course					
I am confident that I can keep my focus on the Norwegian course while using the application					
I am confident that I can complete simple tasks in a Norwegian class in Virtual Reality					
I am confident that I can hold a conversation in Norwegian with another person who is using a virtual avatar					
I am confident that I can use the application intuitively without help					
I am confident that I can ask and answer questions from my teacher in virtual reality					

Interview Guide - Teacher

Introduction

1. Introduce what we will talk about in the interview.
    - The interview will be centered around use of the application
    - You will be anonymous
    - The data will be analysed and used to support the findings in the master's project
    - Be as open and honest as possible
    - Any questions before we start?

Interview Questions

- What were your expectations before the project?
- What were your expectations before the test?
- How was it to use the application?
    a. First impression?
    b. Compared to expectations?
    c. Usability?
- What worked best with the application?
- What could be better or different?
- How was it to teach in VR?
    a. Interact with the students
        i. To talk to them through an avatar
    b. Compared to a traditional classroom
        i. Engagement
            1. Evironment?
            2. Technology?
            3. Interaction with objects?
        ii. How was making assignments in VR?
        iii. How was it to execute the assignments in VR?
- Was there a noticable difference between the two environments (forest and café)?
    a. Both personally or as you observed among the students
- Do you miss anything you would have in a traditional classroom?
- Comments? Other?

Morte, Carlo and Skjæveland, Marton

The effects of a collaborative Virtual Reality application in Norwegian language learning and teaching for immigrants with at least secondary education

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Norwegian University of
Science and Technology