

Magnus Baugerud

# Investigating the Use of Immersive Virtual Reality for Fish Welfare Training and Awareness

Master's thesis in Computer Science

Supervisor: Monica Divitini

Co-supervisor: Ekaterina Prasolova-Førland, Mikhail Fominykh

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Faculty of Information Technology and Electrical Engineering

Department of Computer Science



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# Abstract

Fish welfare is an important concern for the Norwegian aquaculture industry. Immersive virtual reality has become a more prevalent tool used for training and education over the past years, so this thesis investigates how immersive virtual reality can be used for fish welfare training and awareness in the aquaculture industry.

This thesis is written for the research group Innovative Immersive Technologies for Learning at the Norwegian University of Science and Technology, and their ongoing project Virtual Reality for Vocational Education. This project aims to create virtual experiences aimed at introducing young jobseekers to new workplaces.

This thesis has produced an immersive virtual reality application for training its users in welfare inspection of fish on a fish farm. The application aims to simulate the task as accurately as possible to how it is performed at Måsøval fish farm. The inspection task includes counting salmon lice on the fish, looking for gill sickness, and treating the fish as respectfully as possible.

To investigate how effective the application is at training its users or making them more aware of fish welfare, users tests were performed with primarily three user groups: fish farmers, aquaculture students and university students. This was done by having the user try the application and then answer a questionnaire about their experience with it afterward. The fish farmers also participated in an interview.

It was found that the application has some faults that limit its ability to train fish farmers and aquaculture students. With some improvements it may be better at training aquaculture students, but fish farmers are not a good target group for the application, because they have so easy access to the real task the application is simulating. The application did show more promise when it comes to raising awareness for fish welfare for people outside the aquaculture industry.



# Sammendrag

Fiskevelferd er et viktig tema i norsk akvakulturindustri. Oppslukende virtuell virkelighet har også blitt mer fremtredende som et redskap brukt for opplæring de siste årene, så denne oppgaven utforsker hvordan oppslukende virtuell virkelighet kan brukes til fiskevelferds -trening og -kjennskap i akvakulturindustrien.

Denne oppgaven er skrevet for forskningsgruppen "Innovative oppslukende teknologier for læring" (Innovative Immersive Technologies for Learning) ved Norges teknisk-naturvitenskapelige universitet og deres pågående prosjekt "virtuell virkelighet for yrkesopplæring" (Virtual Reality for Vocational Education). Dette prosjektet har som mål å lage virtuelle opplevelser som kan introdusere unge arbeidssøkere til nye arbeidsplasser.

Denne oppgaven har produsert en oppslukende virtuell virkelighetsapplikasjon for opplæring av dens brukere i velferdsinspeksjon av fisk på et fiskeoppdrett. Applikasjonen forsøker å simulere denne oppgaven så virkelighetsnært som mulig til den samme oppgaven som gjøres på Måsøval fiskeoppdrett. I inspeksjonsoppgaven må brukeren telle lakselus på fisken, se etter gjellesykdom å prøve å behandle fisken så respektfullt som mulig.

For å undersøke hvor vellykket applikasjonen er i å lære opp brukeren i eller øke brukerens kjennskap til fiskevelferd ble det gjennomført brukertester. Det var i hovedsak tre brukergrupper som var med på brukertestene: fiskeoppdrettere, akvakulturstudenter og universitetsstudenter. Brukertestene ble gjennomført ved at brukeren først testet applikasjonen og deretter svarte på en spørreundersøkelse om deres opplevelser med applikasjonen. Oppdretterne var også med på et intervju.

Det ble funnet at applikasjonen har svakheter som begrenser dens evne til å opplære fiskeoppdrettere og akvakulturstudenter. Med noen forbedringer kan den kanskje bli bedre til å lære opp akvakulturstudenter, men fiskeoppdrettere er ikke en god målgruppe for applikasjonen, fordi den ekte oppgaven som simuleres er så lett tilgjengelig for dem. Resultatene for applikasjonens evne til å gi folk utenfor akvakulturindustri mer kjennskap til fiskevelferd var mer lovende.



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# Chapter 1

## Introduction

### 1.1 Context

This is a master's thesis written for the Norwegian University of Science and Technology (NTNU), and specifically in collaboration with the research group Innovative Immersive Technologies for Learning (IMTEL). As the name implies, they are researching the use of immersive technologies like virtual reality (VR) and augmented reality (AR) for learning. Previously, IMTEL had a project in collaboration with the Norwegian Labor and Welfare Administration (NAV) called Virtual Internship. The objective of this project was to introduce young jobseekers to different workplaces in a safe and controlled way, through the use of immersive virtual reality (IVR) experiences, in order to help them figure out what career they could be interested in. Throughout this project, multiple such experiences were created, including one centered around being a wind turbine technician, and another around working on a fish farm. Both of these can be read more about in sections 3.1 and 3.3, respectively.

Recently, IMTEL has concluded their Virtual Internship project, but have started a new one in its place. This new project is called Virtual Reality for Vocational Education and Training (VR4VET), and also aims to create virtual experiences designed to introduce young jobseekers to new workplaces. As opposed to the Virtual internship project, VR4VET has a more robust development methodology and more pre-made assets that will make the applications produced in this project more uniform, and therefore easier to pick up for a young jobseeker that has already tried one of the applications. VR4VET also separates the applications into two levels. The first level is applications for users with no knowledge of the workplace, and the second level is for users that has some knowledge of the workplace, and wants to learn a little more. The VR4VET project is a collaboration between NTNU, Techniek College Rotterdam and Technische Universiteit Delft in the Netherlands, Bildungszentren des Baugewerbes e.V., Technische Hochschule Köln in Germany, NAV, and Trøndelag county. Each of the university collaborators have different

focus, with NTNU's focus being the blue sector. (VR4VET 2023)

The blue sector is an important sector in Norway, as Norway is the biggest exporter of farmed salmon in the world (*Laksefakta* 2023). The sector is also growing, and a new export record was set in 2022, with seafood to a value of 150 billion NOK being exported, and 105 of those billions being salmon (*Intrafish* 2023). There are, however, challenges within the fish farming industry, with one of them being the welfare of the fish. In 2022 16.7% of fish in fish farms died before they could be butchered, which is equivalent to 67.4 million fish (*Barentswatch* 2023). This has made fish welfare an important subject for animal welfare organizations, volunteer organizations, regulators, and consumers alike (*Nofima* 2017). This inspired an experts in teamwork (EiT) project in the spring of 2022, that the author participated in. EiT is a subject all NTNU master's students must take that is about learning to work in a team. The project team wanted to create a solution that could help alleviate the fish welfare problem. The result was a non-IVR application where users could look at 3D-models of fish for injuries, sickness, and other welfare indicators. The application was only a proof of concept and was never tested, but it was the inspiration for this master's thesis. It was first investigated if there were any needs for digital tools for visualizing or learning about fish welfare in the research project performed prior to this master's project (Baugerud, 2022). In that project, it was found that it was a need for digital tools that can be used for practical training of students on fish welfare.

## 1.2 Research Goal

The research goal of this thesis is to further investigate the need for digital tools for learning about fish welfare in the aquaculture industry. It is also investigated how IVR can accommodate those needs. This is done by creating an IVR application that aims to teach the user about fish welfare, and testing it on different user groups, like fish farmers, aquaculture students, and other students (A demonstration of the application can be seen on YouTube by clicking this link). Therefore, it is also investigated how to best develop such an application.

## 1.3 Research Questions

**Primary Research Question:** How can fish welfare training and awareness in the aquaculture industry be supported by Immersive Virtual Reality?

**Secondary Research Question 1:** What needs are there for digital tools for visualizing or learning about fish welfare, and what of those needs can be addressed with the affordances of IVR?

**Secondary Research Question 2:** How should an IVR application, used for fish welfare training, be designed to meet the needs of such digital tools?



**Secondary Research Question 3:** How can the use of such an IVR application enhance training for people inside the aquaculture industry and raise awareness for people outside it?



## Chapter 2

# Background

### 2.1 Theory

**NOTE:** Sections 2.1.1 through 2.1.7 are retrieved from the research project that was done as preliminary work to this master's thesis (Baugerud, 2022).

#### 2.1.1 Extended Reality

Extended reality (XR) is an umbrella term for all technologies used to alter or enhance our reality. Both Augmented reality and VR are types of XR technologies. In fact, XR can be described as a spectrum. On one side of the spectrum is augmented reality, with technologies such as the Microsoft HoloLens which allows the user to have a digital overlay over the real world (*Microsoft HoloLens | Mixed Reality Technology for Business 2022*). On the other end of the spectrum is VR, which is usually thought of as technology that immerses the user into a separate virtual world with the use of a head mounted display (HMD) and often controllers tracking the user's hands, that block out the real world. At least that is what one will find with a quick google search. However, there does not exist one official definition of VR, and in fact, there exists a plethora of definition created throughout the last decades by researchers. For example, in 1992 Steuer defined Vr as "A real or simulated environment in which a perceiver experiences telepresence" (Steuer, 1992). In 2016 Lopreiato et al. created a more specific definition: "A wide variety of computer-based applications commonly associated with immersive, highly visual, 3D characteristics that allow the participant to look about and navigate within a seemingly real or physical world. It is generally defined based on the type of technology being used, such as head-mounted displays, stereoscopic capability, input devices, and the number of sensory systems stimulated" (Lopreiato, 2016). This definition emphasizes that the technology usually involves equipment such as HMDs. Even more recently, in 2018, the US department of defense defined VR more broadly again as "An environment represented by models and simulations. This environment is interactive, allowing the participant to look and navigate about the environment,

enhancing the immersion effect." (*M&S Glossary - Terms & Definitions S-W 2022*). This definition can encompass everything from a normal video game played on a screen to the most sophisticated simulations that use HMDs, tracks movement of hands and feet, and stimulate multiple sensory systems. Kardong-Edgren et al. points out that the lack of a standardized definition for VR can lead to confusion and misinterpretations when reviewing literature. They also propose that a definition of VR should have different categories, depending on how immersive the VR is, which is presented in section 2.1.3. (Kardong-Edgren *et al.*, 2019)

### 2.1.2 Immersion and Presence

Before presenting the different categories of VR proposed by Kardong-Edgren et al. it is useful to understand what immersion is. Immersion is a system's ability to present a vivid virtual environment to the user of the system, as well as shutting out the real world. The level of immersion is completely dependent on the technology used to represent the virtual environment, and is therefore an objective measurement (Cummings and Bailenson, 2016). For example, a computer monitor is not able to shut out its surroundings the same way an HMD can, so an HMD is inherently more immersive. Qualities that enhance immersion are the technology's ability to create high fidelity simulations that stimulate multiple senses, its ability to closely replicate the user's real world movement in the virtual environment, and its ability to block out the external world (Cummings and Bailenson, 2016).

Presence is a term closely related to immersion, and it can be easy to confuse the two, but they are fundamentally different. As previously described, immersion is an objective quality of a technology, while presence is a person's feeling of being somewhere. In the context of VR, presence is a user's feeling of being in the virtual environment. For a user to feel presence, it is important that they feel like the virtual environment is a plausible space, and they must feel like they exist within that space. So immersion is a quality of the technology, and presence is a quality of the user's psychology (Cummings and Bailenson, 2016). Immersion is an important factor to facilitate presence, but section 2.1.5 will present two other factors that also facilitate presence.

### 2.1.3 Defining Virtual Reality

As mentioned in section 2.1.1 Kardong-Edgren et al. propose that a definition of VR should categorize different types of VR based on how immersive they are. The three categories they propose are low immersion, moderate immersion and high immersion. Low immersion VR is generally VR used with a computer monitor, that does not block out the surrounding world and requires the use of equipment such as controllers, mouse or keyboard to navigate. Moderate immersion VR has some signals indicating that there is an external world outside the virtual environment, like noise from machinery or movement restricting harnesses. This type of VR

often uses a large screen that gives a bigger field of view than low immersion VR. High immersion VR blocks out most of the surrounding world. This is VR that uses HMDs or surround projection. (Kardong-Edgren *et al.*, 2019)

In this thesis, VR with a high level of immersion is the focus, but VR with a low level of immersion will be mentioned a couple of times. Therefore, the recommendation from Kardong-Edgren *et al.* will be followed, and a distinction will be made between them. High immersion VR will simply be referred to as immersive VR (IVR) and low immersion VR as low immersion VR. "VR" will be used to refer to VR of all immersion levels. Moderate immersion VR is not a subject in this article, and will therefore not be used.

#### 2.1.4 IVR for learning

As previously mentioned, a lot of research is being done on the subject of VR and learning. However, although a lot of research finds the use of IVR to have a positive effect on learning, there is also research that finds mixed results or results refuting IVR's positive effects on learning. In 2019, for example, Leder *et al.* found that there were no real difference in safety training in an IVR application compared to a PowerPoint, and conclude that using IVR for safety training is not worth it because a PowerPoint gives the same learning outcome and is significantly cheaper (Leder *et al.*, 2019). In another study from 2019 Makransky *et al.* found that learning science in both an IVR simulation and a low-immersion VR simulation led to higher motivation, but worse learning outcome compared to traditional learning methods (Makransky, Terkildsen, *et al.*, 2019).

In addition to some research finding IVR to not be more effective than traditional learning methods, and even less effective, there has also been differing opinions on what role VR plays in the learning process. One view is that media has no effect on learning, and that it is only the method used that has any impact on the learning outcome. (Clark, 1994) (Parong and Mayer, 2018). However, Meyer *et al.* performed a study in 2019 where students were taught about cells either through an IVR simulation or with a video. They found that media had an interaction with the method used, meaning media does influence learning outcome (Meyer *et al.*, 2019). Makransky *et al.* also found in 2019, through a study comparing IVR, low immersion VR, and traditional learning methods for safety training in a laboratory, that VR is not that well suited for acquiring factual knowledge, but that IVR is good for transfer of learning. In 2021 Makransky and Petersen argue that the reason that Makransky *et al.* (Makransky, Terkildsen, *et al.*, 2019) found VR to have a worse learning outcome than traditional learning methods is because the experiment focused on factual knowledge, which VR is not suited for (Makransky and Petersen, 2021).

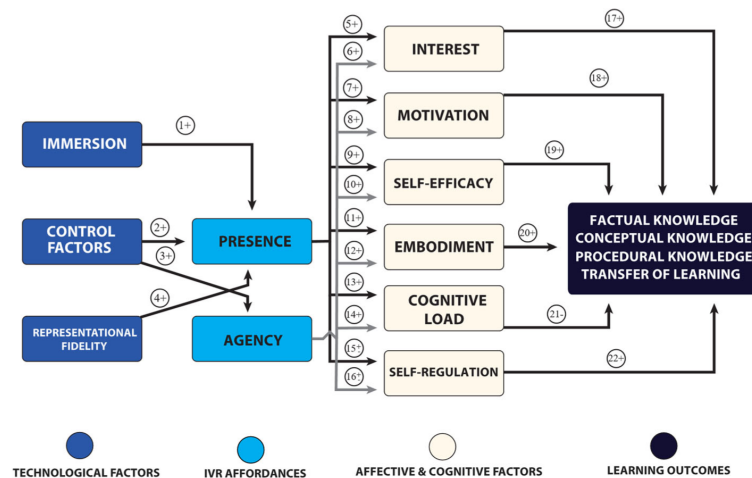
IVR can be a better learning tool than more traditional methods, but in a meta-analysis from 2021 Kaplan *et al.* state that IVR is not better for training than traditional on site training methods. This does not make IVR training simulations

useless, though. In fact, training on site can often be inconvenient, too expensive or dangerous, which makes IVR learning simulations a valuable tool. (Kaplan *et al.*, 2021)

### 2.1.5 The Cognitive Affective Model of Immersion Learning (CAMIL)

The Cognitive Affective Model of Immersion Learning (CAMIL) is a model that aims at describing the process of learning in IVR. The motivation for the creation of the CAMIL is that there are many studies on the use of IVR for learning, but there has been done little work to create a theoretical framework on learning in IVR. The CAMIL uses knowledge from previous research on immersive education to create a description of learning in IVR. (Makransky and Petersen, 2021)

The CAMIL builds on evidence that there is a connection between the method and media used for learning. Using IVR for learning will not automatically yield a better learning outcome than other types of media like video or PowerPoint. Rather, the learning outcome is dependent on whether the learning method used is facilitating the affordances of the chosen media. The CAMIL identifies presence and agency as the main affordances of IVR, so learning methods that facilitate these two affordances will lead to better learning. (Makransky and Petersen, 2021)



**Figure 2.1:** A visual representation of the CAMIL (Makransky and Petersen, 2021).

Three technological factors are presented by the CAMIL that lead to presence and agency. They are immersion, control factors and representational fidelity. An important determinant for presence is the extent of sensory information that is given (Sheridan, 1992). The more immersive the environment is, the more sensory information is given. The amount of control a person has over the sensors and the degree they can modify the environment are also important for the degree of

presence, which is determined by the second factor: control factors. Control factors have to do with the amount of control a person using an immersive learning method has over the environment, which include degree of control, immediacy of control and mode of control (Witmer and Singer, 1998). Finally, the representational fidelity is also important for presence. Representational fidelity has to do with how realistic the environment is, visually, logically and auditory (Dalgarno and Lee, 2010).

Agency, the other affordance of IVR, is only affected by control factors in the model presented by the CAMIL. Agency is to what degree a person is in control of actions, so it is logical that this affordance is directly related to the degree of control a person has in an environment. (Makransky and Petersen, 2021)

As shown in figure 2.1 presence and agency, that are determined by the three technological factors, influence six different affective and cognitive factors, which in turn influence four different types of learning outcomes. The affective and cognitive factors are interest, motivation, self-efficacy, embodiment, cognitive load and self-regulation, and according to the CAMIL they are all factors that contribute to immersive learning. (Makransky and Petersen, 2021)

Interest is defined by the CAMIL as the focused attention of the user on some stimuli. Interest can help the user want to seek knowledge. (Makransky and Petersen, 2021)

Motivation means to engage in an activity just for the satisfaction of doing the activity. So, a person is motivated to do a task if simply doing the task is satisfying. The CAMIL also states that the perceived presence of another person, meaning another person or a non-playable character (NPC), can increase motivation. (Makransky and Petersen, 2021)

Self-efficacy is a measure of a person's belief in their ability to execute behavior required to reach a specific goal. High self-efficacy for a specific goal can make a person more motivated for reaching that goal and more confident that they can reach it. The opposite is true for low self-efficacy. (Michael P. Carey, 2009).

Embodiment means to feel ownership over a body. For IVR, this means feeling ownership over one's virtual body. The external appearance of the body, one's control over the body, and the ability to feel sensory events targeting the body (Makransky and Petersen, 2021).

Cognitive load is a term used in cognitive load theory (Sweller, 2011) and the cognitive theory of multimedia learning (Mayer, 2014). Cognitive load theory suggests that humans have a working memory (similar to how computers have RAM) that is being used when we try to learn something. cognitive load is the taxation on our working memory when we are learning. This is important for IVR, because the cognitive load theory suggests technological learning methods, due to presenting info in forms like audio or animations rather than text, have a higher cognitive

load. If the cognitive load exceeds the capacity of working memory, it may have a negative impact on learning (Sweller, 2011).

Self-Regulation refers to a person's ability to regulate their behavior, and not give in to impulses or distractions. (Makransky and Petersen, 2021). Immersive learning methods can be used for learning self-regulation, but can also contain seductive elements that have the potential to distract users (Moreno and Mayer, 2002). One aspect that can increase self-regulation is the perceived presence of another person. And aspect that can lower it is interactive objects unrelated to a task in the immersive environment.

As mentioned in the previous section, the six affective and cognitive factors influence four different learning outcomes. These are factual knowledge, conceptual knowledge, procedural knowledge and transfer of learning. (Makransky and Petersen, 2021)

The CAMIL defines factual knowledge as "knowledge of discrete, isolated content elements or "bits of information".", for example knowledge of specific details or terminology (Makransky and Petersen, 2021). Conceptual knowledge is knowledge about more complex information. This can be concepts, theories, models, etc. The CAMIL also suggests that Immersive learning is less suited for factual knowledge than it is conceptual knowledge. A study from 2018, for example, found VR lessons to be less effective than PowerPoint lessons for factual knowledge, and no significant difference for conceptual knowledge (Parong and Mayer, 2018).

Procedural knowledge is knowledge about how to do something. Specifically, it is knowledge of procedures that one can perform without having to consciously having to recollect how to perform (Makransky and Petersen, 2021). Knowing how to drive a car or how to play an instrument are examples of such knowledge. This type of knowledge is the type that is most often taught with IVR (Radianti *et al.*, 2020). A reason for this is that IVR can easily reconstruct scenarios that are dangerous or impractical to do in real life.

The final learning outcome described by CAMIL is transfer of learning, which means to transfer knowledge learned in one context over to another. For IVR this would often mean transferring knowledge gained from an IVR learning application over to the real scenario the IVR application was simulating. (Makransky, Borre-Gude, *et al.*, 2019)

### 2.1.6 Workplace training with IVR

There have already been done some research at NTNU on using IVR for workplace training. Section 3.1 describes a previous master's thesis written for IMTEL that have created a virtual internship application. It found users to have a better understanding of the workplace simulated after trying the application. In 2019 Prasolova-Førland *et al.* also tested two IVR applications, one meant for interview training, and one meant for introducing the user to working on a fish farm. They



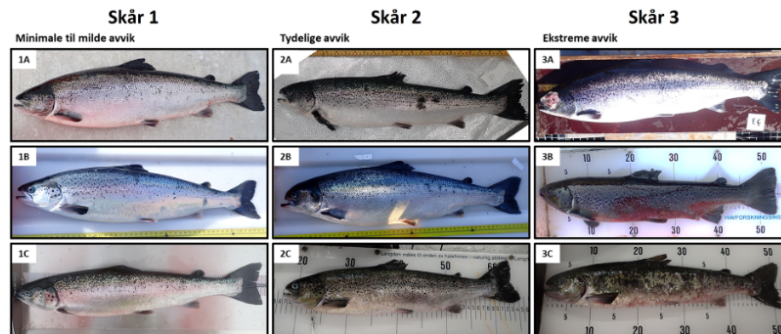
tested the application on both young jobseekers and welfare professionals. They found the participants to be positive towards using the applications for training. They also found the fish farm application to be more popular than the interview training application. The fish farm application used 3D modeled environments and was described as more interactive, compared to the interview training application, which used 360° video instead. (Prasolova-Førland *et al.*, 2019)

The aforementioned papers all focused on IVR applications that introduce the users to the workplace. Meaning, they teach the basics of the job is about, but nothing more than that. Some studies exist that focus more on applications training users how to actually do the job. A study from 2018 investigated the effects of using an IVR application for teaching workers at a manufacturing factory to assemble different items. In the study, they found that users that used the IVR application for training never performed worse than the ones that trained with a PowerPoint presentation, and that they in many cases performed better (Abidi *et al.*, 2019). This shows that using IVR for workplace training can lead to more acquirement of procedural knowledge and transfer of learning. A study in 2019 investigating the use of IVR and low immersion VR for laboratory safety training also found IVR to yield higher transfer of learning (Makransky, Borre-Gude, *et al.*, 2019). It was also a systematic review from 2021, about the use of IVR for professional training, that points out the usefulness of IVR in simulating workplace training where real world training can be unsafe or outright impossible (Renganayagalu *et al.*, 2021).

All the studies mentioned in this section has had some kind of IVR application that tries to accurately and realistically simulate a real world workplace. This is no coincidence. In a paper from 2015 discussing different approaches to making immersive workplace training applications, one of the most important aspects highlighted is that the realism of the environment simulated is important. Higher realism of the workplace simulated leads to higher immersion (Grajewski *et al.*, 2015).

### 2.1.7 Laksvel

In the research done for this master's thesis, no papers have been found that focuses on using IVR in the fish welfare field. One new development in the field that is worth mentioning, though, is Laksvel. Laksvel is a protocol meant to standardize how fish welfare is evaluated. Though the fish farm industry for a long time has documented and evaluated welfare of the fish, no standard existed, which Laksvel attempts to remedy. The protocol describes various operative welfare indicators (OWIs) one should look for on a fish. This can be things such as spinal deformities, salmon lice or fin damages. The protocol also describes how to rate OWIs from zero to three, where zero is no deviation and three is extreme deviation. Very few fish have a perfect exterior, though, so zero is rarely used. (Nilsson *et al.*, 2022)



**Figure 2.2:** Fin injuries, shell loss and emaciation rated sorted from top to bottom showing scores 1 to 3 (Nilsson *et al.*, 2022).

Laksvel is heavily based on its predecessor Fishwell. Fishwell was only a handbook, and did not describe a protocol for evaluating welfare like Laksvel does. The use of Laksvel can help get a more standardized measure of the welfare of fish across the entire fish farming industry, which can help increase the welfare of the fish as well.

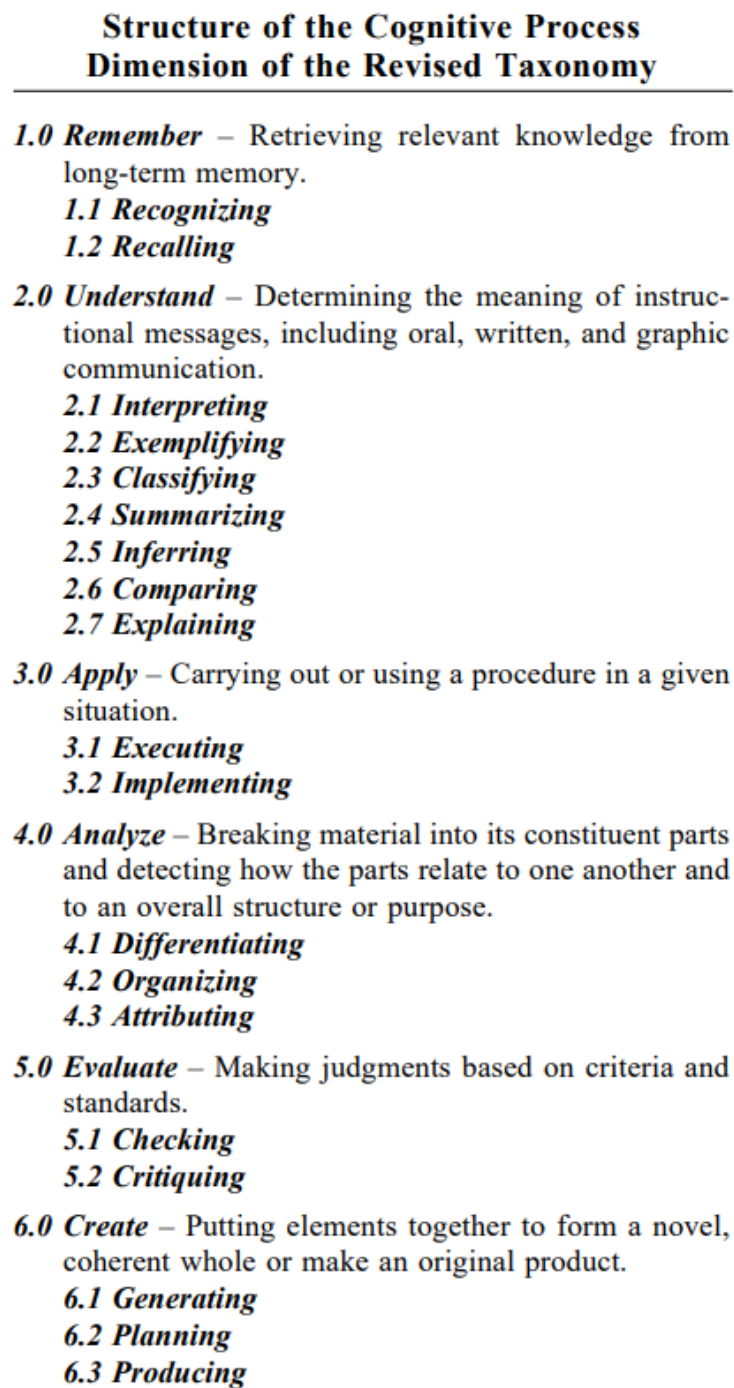
### 2.1.8 Blooms Taxonomy

Bloom's taxonomy is a framework that can be used to classify different levels of learning outcomes. The taxonomy consists of three domains: Cognitive, affective and psychomotor (Hoque, 2016). The taxonomy is meant to be used as a tool that can determine what learning outcomes are provided by a course, curriculum, learning objective or tool, as well as giving educators a common language for learning goals (Krathwohl, 2002). The two following sections will describe the cognitive and affective domains of Bloom's taxonomy. The psychomotor domain will not be presented in this thesis, as it is not relevant for the application.

#### The Cognitive Domain

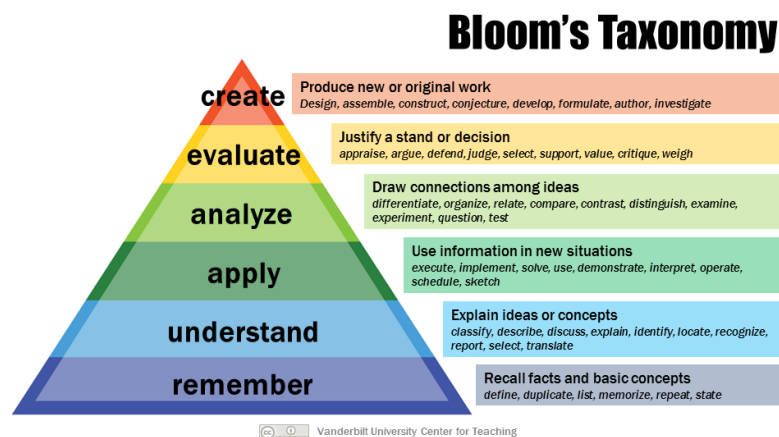
The cognitive domain was originally described in 1956 by Benjamin S. Bloom, but was revised by Anderson, Krathwohl, et al. in 2001 (Krathwohl, 2002). This revised version is the one that will be covered here. The domain is divided into six categories, with each category representing a different level of learning. The categories are also divided into sub-categories (Krathwohl, 2002). Figure 2.3 shows these six categories, and their sub-categories.

The cognitive domain of Bloom's taxonomy is often represented by a pyramid, as shown in figure 2.4. This is because there is a hierarchy to the domain. The *remember*-level is the first level in the domain and considered the simplest. It only entails remembering and recognizing discrete pieces of information. The sixth and final level of the domain is create, that involves producing original content, and is therefore considered the most complex level. The lower levels are also often



**Figure 2.3:** The six categories of learning in Bloom's taxonomy (Krathwohl, 2002).

considered prerequisites for the higher levels, which is why a pyramid is a good representation (Krathwohl, 2002). However, (Krathwohl, 2002) also points out that this is not hard hierarchy with no exceptions. It is more of a spectrum, and one can find learning objectives in a lower level that can be considered more complex than that of one in a higher level.



**Figure 2.4:** A common representation of the six tiers of learning in the cognitive domain of Bloom's taxonomy (Armstrong, 2010).

One of the changes made in the revision of the cognitive domain of Bloom's taxonomy is that it was divided into two dimensions (Krathwohl, 2002). The one that has been described so far in this section is simply called the cognitive dimension. The other is the knowledge dimension, which can be seen in figure 2.5. This dimension covers the different types of knowledge. Learning objectives can be classified in both the cognitive and knowledge dimension, which is what makes the domain two-dimensional (Krathwohl, 2002). When classifying a learning objective, it is often classified with a noun in the knowledge dimension and a verb in the cognitive dimension (Krathwohl, 2002). For example, a learning objective could be "The student should be able to count salmon lice on a fish.". In this case, the verb would be "count", which falls under category 3.0 *Apply*, specifically 3.1 *Executing*. The noun is "salmon lice", which can be classified as procedural knowledge, specifically *Cb. Knowledge of subject-specific techniques and methods*, in the knowledge dimension. As counting salmon lice is an important task in the application created for this thesis, it is then clear that the learning that will be done in the application falls under the cognitive domain in Bloom's taxonomy.

It can also be helpful to make a two-dimensional table to see what categories of knowledge and cognition are covered by one or multiple learning objectives, as can be seen in figure 2.1. This helps to see if a learning plan or objective covers the right categories, or if some needs to be covered more. Often *remember* is extensively covered in learning plans, but the other categories 2.0-6.0 are the ones more desirable in education. (Krathwohl, 2002)

### Structure of the Knowledge Dimension of the Revised Taxonomy

---

- A. *Factual Knowledge*** – The basic elements that students must know to be acquainted with a discipline or solve problems in it.
    - Aa. Knowledge of terminology**
    - Ab. Knowledge of specific details and elements**
  - B. *Conceptual Knowledge*** – The interrelationships among the basic elements within a larger structure that enable them to function together.
    - Ba. Knowledge of classifications and categories**
    - Bb. Knowledge of principles and generalizations**
    - Bc. Knowledge of theories, models, and structures**
  - C. *Procedural Knowledge*** – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.
    - Ca. Knowledge of subject-specific skills and algorithms**
    - Cb. Knowledge of subject-specific techniques and methods**
    - Cc. Knowledge of criteria for determining when to use appropriate procedures**
  - D. *Metacognitive Knowledge*** – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.
    - Da. Strategic knowledge**
    - Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge**
    - Dc. Self-knowledge**
- 

**Figure 2.5:** The four categories of knowledge in Bloom's taxonomy (Krathwohl, 2002).

	The cognitive process dimension					
The Knowledge Dimension	1. Remember	2. Understand	3. Apply	4. Analyze	5 Evaluate	6. Create
A. Factual Knowledge						
B. Conceptual Knowledge						
C. Procedural Knowledge			X			
D. Metacognitive Knowledge						

**Table 2.1:** The learning objective "The student should be able to count salmon lice on a fish." deconstructed into the cognitive and knowledge dimensions.

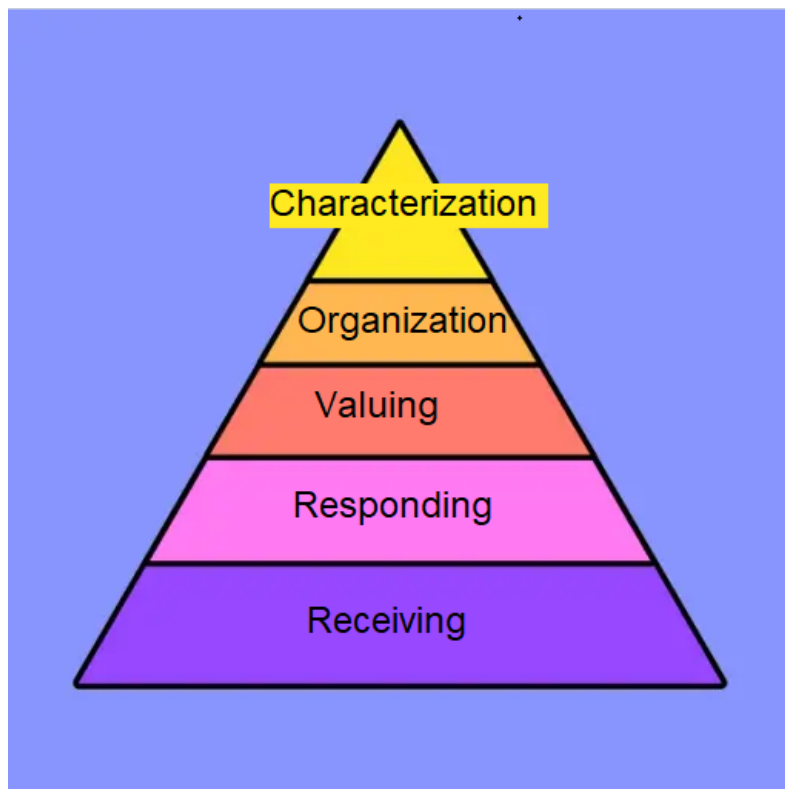
### The Affective Domain

The affective domain was first described in 1964. Similar to the cognitive domain, the affective domain is also divided into levels, though the affective domain only has five levels, which are *receiving*, *responding*, *valuing*, *organization*, and *characterization*. There is also a hierarchy to these levels, with *receiving* being the lowest, and *characterization* being the highest, and can therefore be visualized in a pyramid too, as can be seen in figure 2.6. (Hoque, 2016)

As mentioned, *receiving* is the lowest level in the affective domain. It entails simply being aware of a feeling or emotion, and being able to focus on it (Hoque, 2016).

The *responding* level involves partaking in the learning process. The stimuli is not simply being received, it is being acted on (Hoque, 2016).

The third level, *valuing*, is about the ability to value something, and to express that value. The degree of *value* can vary from simple acceptance to a complex commitment. (Hoque, 2016)



**Figure 2.6:** The affective domain of Bloom's taxonomy represented as a pyramid.

The *organization* level involves being able to rank and prioritize different values over other values (Hoque, 2016).

*Characterization*, the final level, is when values are actually internalized and dictates how a person acts (Hoque, 2016).

As the application made for this thesis tries to teach the user the importance of fish welfare and treating the fish with respect, which means affective learning is also important. The user should both recognize and act on the need to handle the fish respectfully.

### 2.1.9 Gestalt principles

The Gestalt principles is a set of principles about how humans process visual information, that can be utilized to create user-friendly user interfaces. There are seven principles, which are proximity, similarity, closure, continuity, symmetry, common fate and Figure-ground. Although these principles traditionally has been applied to graphical design, it has been found that they also apply in an IVR environment. (MacNamara, 2017)

The rest of this section will give a brief explanation of all the Gestalt principles.

The principle of proximity: Objects that are closer to each other are related, and that objects that overlap are the most related. (MacNamara, 2017)

The principle of similarity: Objects that look similar to each other are perceived as being part of the same group. (MacNamara, 2017)

The principle of symmetry: Objects that are placed in a symmetrical layout are often easier for people to remember. (MacNamara, 2017)

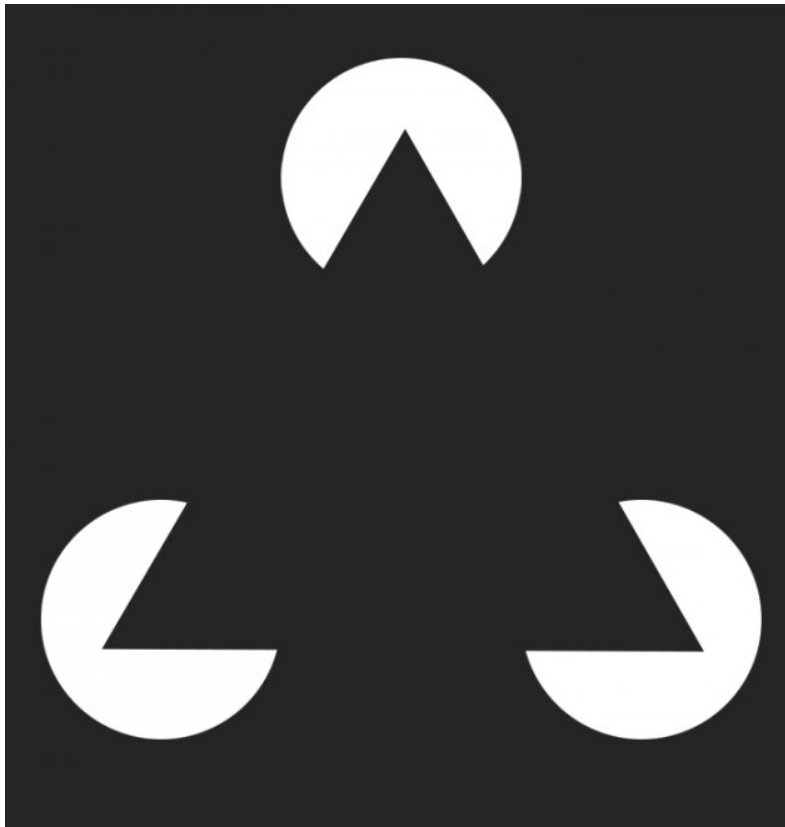
The principle of Closure: Objects organized in a system can be perceived as a pattern, instead of a clutter of independent objects. Figure 2.7 demonstrates this principle. (MacNamara, 2017)

The principle of continuity: If a part of a linear pattern is obstructed by something, the human brain will often continue following where it believes the pattern to be, expecting the pattern to continue on the other side of the obstruction. (MacNamara, 2017)

The principle of common fate: Objects that move together are perceived as being in the same group, and are unrelated to objects that move differently to them. (MacNamara, 2017)

The principle of figure-ground: Some objects will be perceived as being in the foreground while another is in the background (Todorovic, 2008). This is illustrated in figure 2.8.





**Figure 2.7:** A figure demonstrating the principle of closure. One can see the triangle without it being fully drawn (*7 Gestalt Principles of Visual Perception* 2023).



**Figure 2.8:** A figure demonstrating the principle of figure-ground. The image to the left will, by many, be perceived as two faces, while the one on the right as a chalice (*Exploring the Gestalt Principles of Design* | Toptal® 2023).

## 2.2 Research Project

In the autumn semester of 2022, a research project was performed as a preliminary project to this thesis. The results of that research project informed the direction and focus of this master's thesis. This section will summarize the project. (Baugerud, 2022)

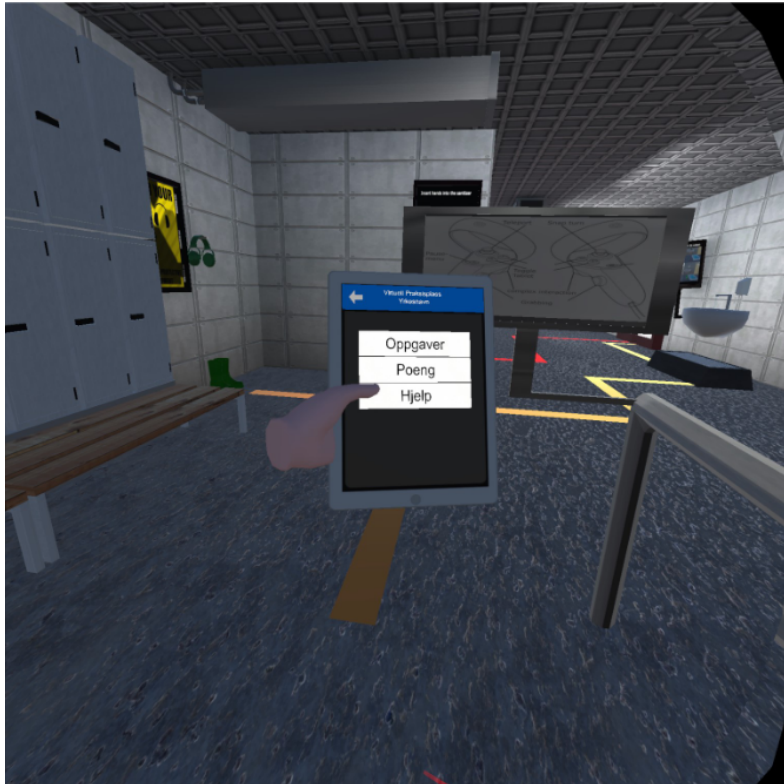
The work done during the project can be divided into three different parts, not in time, but in the nature of the work. The first part was a literature review on the use of IVR for learning and for workplace training. As described in section 2.1, sections 2.1.1 through 2.1.7 are retrieved from the research project. This is relevant theory that was found during the literature review. (Baugerud, 2022)

The second part was three interviews with fish welfare experts that were performed during the research projects. Two of the experts were university professors at the university in Tromsø (*UiT Norges arktiske universitet* | *UiT* 2023), and the other was a researcher at Nofima (*Nofima* 2023). The purpose of the interviews was to find out if it was a need for digital tools for visualizing and learning about fish welfare and how students were taught about fish welfare. It was found that it was a need for digital tools that could be used by students for practical learning about fish welfare. This was because the university professors could not provide the students with adequate amount of real practical lessons on fish welfare, and because fish used for practical training with students must be euthanized. All fish farmers must also take a course every five years that includes fish welfare as a subject, but it has no practical lessons. This could be another potential need for digital tools. The experts were also positive to the idea of using IVR, in particular. This was because it could accurately simulate practical lessons done in real life. (Baugerud, 2022)

The third part of the work was an empirical study of IMTEL's most recent workplace training application, which was about working on a fish processing facility. The application is described in more detail in section 3.4. As the application was designed for introducing young jobseekers and school pupils to the workplace, they were the user groups that were tested. In addition, the application was tested on career counselors, who aid young jobseekers in finding jobs, and therefore could provide good feedback on the viability of the application. (Baugerud, 2022)

During the empirical study, the application was tested at two different events, one was an event hosted by Prima (*Prima* 2023) for jobseekers and career counselors, and the other was a career day event for 10th grade pupils hosted at Verdal high school. It was also tested during three visits by career counselors to IMTEL's VR lab. Finally, in collaboration with NAV, the application was tested on young jobseekers at one of NAV's locals. (Baugerud, 2022)

From the testing, it was found that most users seemed to get a better understanding of the job represented in the application, and how to perform the tasks in



**Figure 2.9:** A screenshot from IMTEL's latest Fishery VR application. The user is holding the tablet (Nilashan *et al.*, 2022).

the job. They also thought the application would be helpful for career guidance at schools. There were, however, some issues found with the application. The biggest problem was that users had trouble figuring out where to go. Some users struggled with handling the fish, as it could only be held in one way, and the fish were entirely stiff. The users also had difficulties gutting the fish, largely due to poor feedback on when they had done it right or wrong. In the gutting task, some users also did not understand where to put the live fish. Also due to lack of feedback, many users did not know when they had completed a task. Finally, many users did not use the tablet that was in the application. The tablet would give users information on where to go, what to do in the different tasks, and it kept track of the user's skills. It seemed that some users did not use the tablet because they did not understand how to access it. Others were able to access it, but had difficulty using it. (Baugerud, 2022)



## Chapter 3

# Related Work

**NOTE:** Section 3.1 is retrieved from the research project that was done as preliminary work to this master's thesis (Baugerud, 2022).

This chapter will present four projects that are of particular relevance for this project. Section 3.1 describes a project with an application designed for workplace training, which is relevant because this thesis has also produced a workplace training IVR application. Section 3.2 is about an IVR application related to animal welfare, which is an important aspect of the application created in this thesis. Finally, sections 3.3 and 3.4 are both about IVR applications used for workplace training, but they are specifically about the aquaculture industry. This makes them workplace training applications of particular interest, as this thesis' application is also about the aquaculture industry.

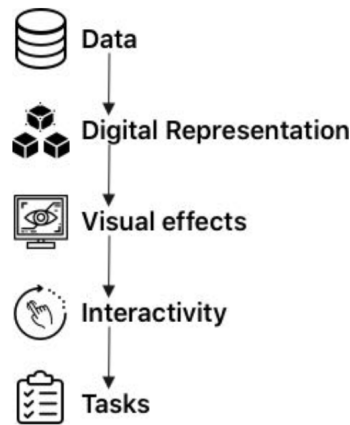
### **3.1 Engaging Young Job Seekers with an Internship as a Wind Turbine Technician in Virtual Reality**

This is a master thesis written in 2019 in collaboration with IMTEL and its ongoing project with NAV (Henrichsen, 2019). Part of the work on the paper involved making a virtual internship applications. This makes it an interesting paper for this thesis, is as this thesis produced an application for VR4VET, the project succeeding virtual internship. The application created in the 2019 paper is WindturbineVR and introduced its users to working as technician on a win turbine. In the application, the user can walk around the turbine and climb up into it in order to perform maintenance tasks.

The paper found through user tests that the virtual internship application does seem to have value. the people that tested the applications were jobseekers and career counselors at NAV. The results from the tests showed that the users felt they had a better understanding of what the job was about after trying the application, and that they believed the application should be used in career counseling. The

paper does however point out that the results only are the opinions of jobseekers and counselors. The application has not actually been tested in a real career counseling scenario, so there is no evidence supporting that the application actually would make the career counseling process better. (Henrichsen, 2019)

Another artifact produced by the thesis, in addition to WindturbineVR, is a five-step process from reality to virtuality. This is a process for bringing objects, components, or "parts" from the real world work place into the virtual work place. It is not a process describing how to develop the entire application, only single components. The five steps are data, digital representation, visual effects, interactivity, and tasks. (Henrichsen, 2019)



**Figure 3.1:** A visual representation of the five-step process from reality to virtuality (Henrichsen, 2019).

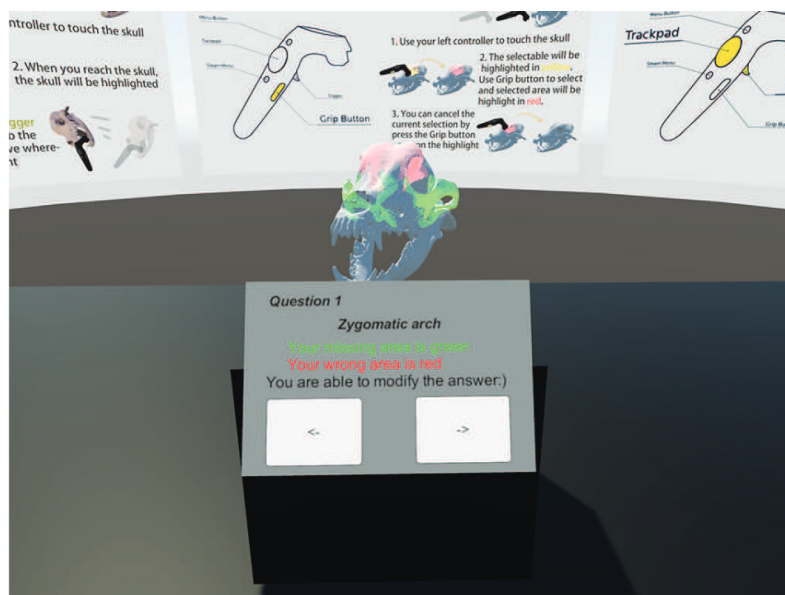
The data step involves gathering data about the object. This involves information on things such as what the objects look like, what properties it has and its size. The second step, digital representation, is visualizing the object digitally, whether that is done manually or through a process like scanning. The visual effects step involves adding things to the object such as textures, normal maps, lighting and graphical effects. In the interactivity step, aspects like colliders, physics and other logical features of the application are added. Finally, in the tasks step, the tasks of the workplace have to be designed and implemented around the objects. (Henrichsen, 2019)

In the development of WindturbineVR one of the focus areas was on having high graphical and auditory fidelity. This is because that leads to immersion, which leads to presence, which Henrichsen states is an important aspect of IVR games. He also points to research naming control as an important aspect of games, but control or agency is not emphasized in his thesis. (Henrichsen, 2019)

### 3.2 Delaying when all Dogs to go to Heaven : Virtual Reality Canine Anatomy Education Pilot Study

In 2018 a study was conducted on the use of IVR in anatomy training. This study focused specifically on dog anatomy. It also focuses on summative assessment instead of formative assessment. This means the focus is on using IVR as a tool for testing the skill and knowledge of a user, rather than teaching it. (Xu *et al.*, 2018). This project is interesting to this thesis, as it involves inspecting animals in IVR, which is an integral part of the application produced for this thesis.

The study compared the normal multiple choice exam (MCQ), that veterinary students normally would take, with an IVR experience where the users could view the cranium of a dog in IVR and answer questions. They also made two different versions of the application. One were simplified and let the user press a button on a screen in the IVR app to answer questions. This version was made because most people were not familiar with IVR at the time, and may therefore have difficulties using the technology. In the more complex version, users were given names of part of the cranium, and then the user would have to color that part of the cranium in the application. (Xu *et al.*, 2018)



**Figure 3.2:** A screenshot from the complex version the IVR application created for the study (Xu *et al.*, 2018).

The study found that most participants preferred both the IVR applications over the paper MCQ. They stated the reason for this was that the IVR applications were more interactive and made it easier to visualize. One participant did, however, comment that it was harder to transfer their mental image of the anatomy of the animal over to the exam. This may, however, have been due to inaccuracies in the

3D model of the cranium. (Xu *et al.*, 2018)

### 3.3 Empowering Young Job Seekers with Virtual Reality

In 2019 Prasolova-Førland *et al.*, 2019 released a paper on an ongoing project called "Virtual Internship". The project created IVR applications simulating different workplaces, that were meant to introduce young jobseekers to different workplaces, so they could get a "taste" for them. These applications were not made for training the jobseekers or employees, only introduce the workplace, as young jobseekers often have low self-esteem and self-efficacy. These applications are also meant to remedy that. (Prasolova-Førland *et al.*, 2019)

The paper covers the two applications that had been the furthest developed at that point, which were a job interview training application, and a fishery training application. The fishery application, called FisheryVR, is the one most relevant for this thesis, as it is about workplace training in the blue sector. In it, users can try six different tasks related to either fish farming or fish processing. The user can also move freely between a fish farm and a processing facility using a boat.

Through user testing with young jobseekers, they found that most user found the applications enjoyable and valuable, and they would want the application to be used for career guidance.



**Figure 3.3:** A screenshot from the FisheryVR application and a user testing it using the HTC Vive (Prasolova-Førland *et al.*, 2019).

The paper also comes with multiple recommendations for the development of future career guidance IVR applications. Among these is the importance of balancing game elements. The application needs to be engaging, but aspects of the application should not distract from the main task. The paper also recommends giving good feedback to the user. This can be things such as sounds or scores. But more advanced feedback like NPCs emulating coworkers or supervisors should



be considered. The FisheryVR application uses 360° videos to demonstrate tasks, which are cheap to produce, but it is unclear if they are better than an interactive IVR demonstration. The paper also recommends following their methodology for developing new apps, which includes having a realistic environment, giving key information, and giving the user a score on different competences as they complete tasks. The application should also offer the user an experience that is interactive but not as complex as the real job. The application should also be evaluated on both user experience and perceived usefulness. (Prasolova-Førland *et al.*, 2019)

### 3.4 Improved FisheryVR

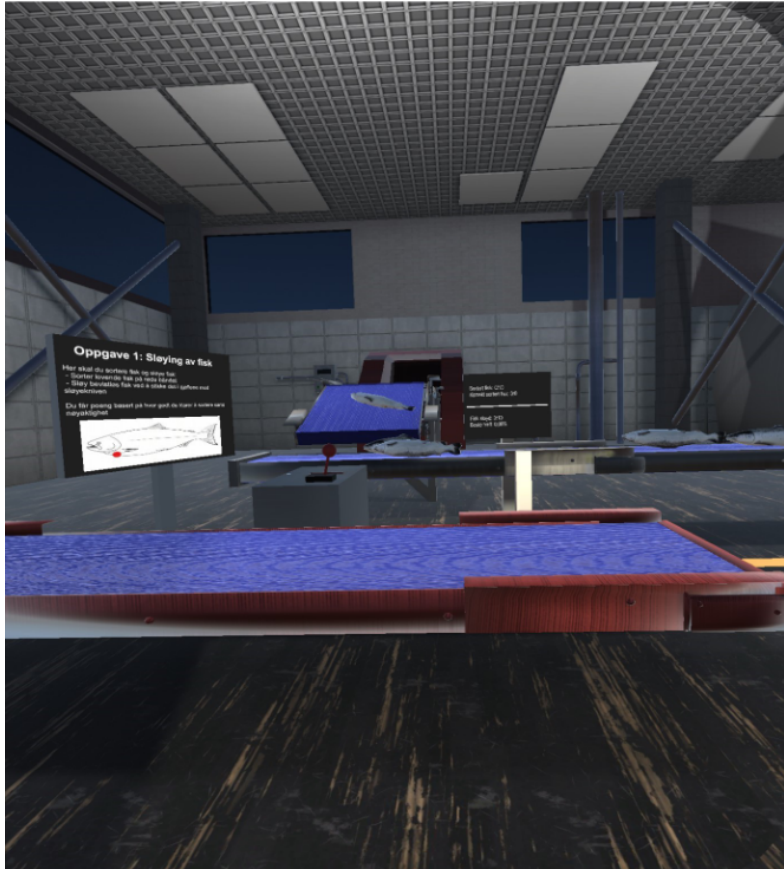
In the spring of 2022 a team of bachelor students made an improved version of the FisheryVR application presented in section 3.3, and were able to reuse some of the assets from the old application. They focused on the fish processing facility part of the application and made four tasks that young jobseekers can try. The fish farm is not a part of the application. (Nilashan *et al.*, 2022). This is another virtual internship application about the blue sector, making it very relevant for this thesis. In the research project preceding this master's thesis, it was investigated further, which is described in section 2.2

The first task in the application is a safety and hygiene routine. The user have to put on ear protection and wash their hands and boots. The second task is about gutting fish on a conveyor belt, and removing live fish. The third task is about removing discoloration from fish fillets, and the final task is about sorting different products. These tasks follow the recommendations of (Prasolova-Førland *et al.*, 2019) by giving interactive experiences emulating real tasks done in a fish processing facility without being as complex. They also assign different skills to the tasks, like accuracy and supervision. (Nilashan *et al.*, 2022)

The product owners for the application were IMTEL and NAV, and by the end of the project the student team had made an application that satisfied the product owners and their requirements. Throughout the development, the team performed user tests to make sure the application functioned properly. These tests were not a focus of their final report, though, and are therefore not well documented in it (Nilashan *et al.*, 2022). No final testing of the application is mentioned either, only that the product owners were satisfied with the final result. However, as previously mentioned, the application was investigated in the research project described in section 2.2.

### 3.5 Related work with limited information

Throughout the research for this thesis, no published academic articles were found that focus on aquaculture workplace training, besides the ones affiliated with IM-



**Figure 3.4:** A screenshot from the fish gutting task in the improved FisheryVR application (Nilashan *et al.*, 2022).

TEL. During the research, Google, Google Scholar and web of science were used to search for articles. The following phrases were used when searching: "Aquaculture VR", "Aquaculture Virtual Reality", "Fish farming VR", "Fish farming Virtual Reality", "Aqua VR", "Aqua Virtual Reality", "Aqua industry VR", and "Aqua industry Virtual Reality". There were, however, two projects were found that on the subject, but that lacked any academic publications. Therefore, it was only limited information found on these projects, but what was found will be presented in this section.

### 3.5.1 AquaVR: RAS training in Virtual Reality

A video of one of the researchers presenting this projects is the only information that was found on this project. As of the publication of the video (26th of March 2021) the project was still ongoing. In the project, an IVR application is being developed that will allow users to train on operating a recirculating aquaculture system (RAS) (AquaVR 2021). A RAS recycles the water used in the aquaculture,

which means it can be stationed on land (*Recirculating aquaculture system* 2023). From what is shown in the presentation, users do not directly interact with fish in this application, but rather the RAS, which requires maintenance to ensure the welfare of the fish in the aquaculture.

### 3.5.2 CareerLabsVR: Aquaculture Technician

CareerLabsVR create different IVR applications that allow the user to explore different jobs. One of these jobs is aquaculture technician. Only a video trailer and a small description of the application is freely available. The video shows a user feeding fish in an aquaculture and steering an underwater drone. In the small description, it is advertised that one of the tasks is to keep the fish health optimal, but what this entails is not elaborated on. CareerLabsVR was reached out to, in an effort to gather more information, but they did not respond.

## 3.6 Features

This section shows what features the applications have, that the IVR application that will be made in this master's project, must have. Table 3.1 shows the comparison of all the features. Cells with "✓" means that the corresponding application has that feature, and "÷" means it has it, but to a limited extent. Most of the applications discussed in this chapter did not have a name, so names that describe what they do are used in table 3.1. To avoid any confusion, table 3.2 shows what application belongs to what section in this chapter.

Features	Related work			
	Windmill VR	Dog Anatomy	Virtual internship	Improved FisheryVR
IVR	✓	✓	✓	✓
Real-world simulation	✓		✓	✓
Workplace training		✓	✓	✓
Blue sector			✓	✓
Animal welfare training		÷	÷	
Realistic animal interaction			÷	÷

**Table 3.1:** A table showing what functionality the applications from related work have, that the application in this project will have.

Application	Section
Windmill VR	Section 3.1
Dog Anatomy	Section 3.2
Virtual Internship	Section 3.3
Improved FisheryVR	Section 3.4

**Table 3.2:** This table shows what application belongs to what section in the related work chapter.

## Chapter 4

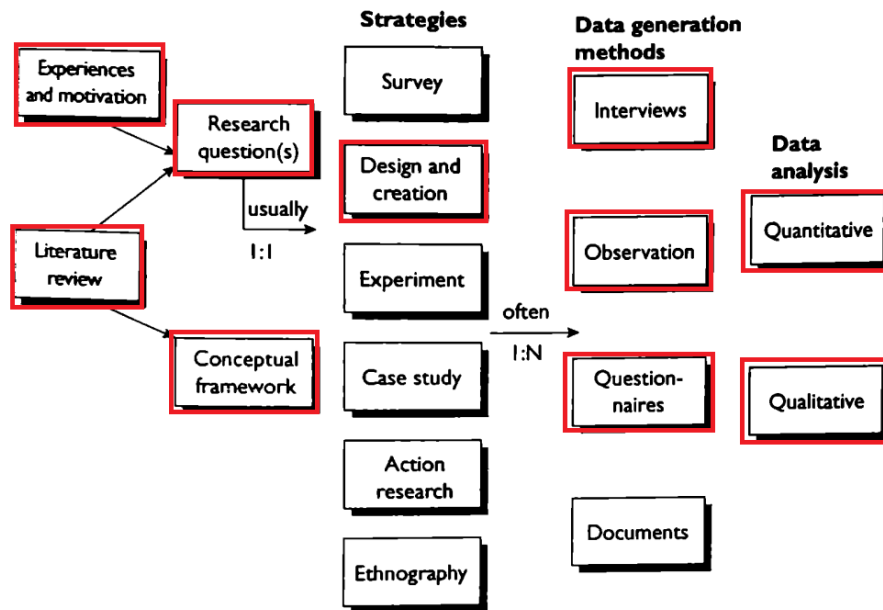
# Method

In this project, an application has been developed and tested to answer the research questions posed in section 1.3. This chapter will describe the methods used in the research, development and testing.

### 4.1 Research Method

This project bases its research strategy on design and creation, one of six research strategies for computer science presented by Oates *et al.*, 2022. The focus of this strategy is that it will produce an artifact, either a construct, model, method, or instantiation. This project will produce an IVR application, which is a type of instantiation. Oates *et al.*, 2022 also distinguishes between three different focuses a design and creation research project can have. One focus can be the application itself, another is the process of developing the application, and the last is one where the application is used to achieve another goal. The latter one is what will be used in this project, as the application will be tested on different user groups, and the results from the testing is what will contribute to the knowledge base.

The testing methods that will be utilized in this project are interviews, observation and questionnaires, which will produce both quantitative and qualitative data that will be analyzed. Figure 4.1 illustrates the method. Finally, in a research project done before this project, a case study was performed by testing the latest blue sector application produced by IMTEL (Baugerud, 2022). The knowledge gathered from that project will be used to inform decision-making in this project.



**Figure 4.1:** The research process used in this project. Figure retrieved from (Oates *et al.*, 2022). The items with red outline is used in this project.

## 4.2 Development methodology

During the development of the application created for this project, some agile methods were used. Throughout the project, the application was continuously iterated on. Each iteration was tested, and feedback acquired from the testing would be used to inform further development, update requirements, and revising the development methodology. Although there were multiple iterations, there were no sprints that were planned out. This is because it was considered more overhead than necessary in a one-man project.

As this project was written in collaboration with IMTEL and their VR4VET project, this project utilizes both some of VR4VET's own methodology and assets (VR4VET 2023). VR4VET continues the work of IMTEL's old project, Virtual Internship, in creating IVR applications that young jobseekers can test in order to get a taste for different workplaces. VR4VET is aiming to make applications for users of two different types: Those that have no preliminary knowledge of a workplace, and those that have some. This master projects aim to make an application that can be used by professionals and students of the field, in addition to users with no preliminary knowledge, though. This fact, in addition to VR4VET being a work in progress project, means not all of its assets and methodology ended up being used in this project.

VR4VET provides a structure for how to simulate a workplace in IVR for young

jobseekers. The workplace should be divided into separate tasks that are done in that workplace. Each task should also be divided into smaller subtasks, and subtasks are divided into steps. Assessment, sequencing, supportive information, procedural information and part task practice are important for the different levels of the task. Table 4.1 shows what level of a task requires the different aspects. Assessments means that the user gets assessed in some way for the work they do. Sequencing means the subtasks or steps must happen in a specific order. Supportive information is information about why a task is done, while procedural information is how it is done. Finally, part task practice means the step can be repeated multiple times for practice. (VR4VET 2023)

Structure element	Assessment	Sequencing	Supportive information	Procedural information	part task practice
"Complex" tasks	Must have	N/A	Must have		
Subtask	Must have	Must have	Must have		
Step	N/A	Can have		Can have	Can have

**Table 4.1:** VR4VET's structure of workplace tasks.

Each task in the application should also be connected to a skill. These skills vary based on the workplace and task. By performing a task the user will increase their skill related to that task. The skill is a number tracked by the application, not the user's actual real world skill. The skills are meant to give a user an idea of what skills are required in the workplace. (VR4VET 2023)

According to VR4VET's methodology, the tasks that are selected for simulation in the IVR application should be tasks that are done daily by the employees, and tasks that are done by trainees should be prioritized. Also, information on the tasks that are selected for simulation should be gathered through interviews with the employer and other sources. (VR4VET 2023)

VR4VET's methodology was followed when possible in this project, but as previously mentioned, there are differences between the application that will be created for this project and the applications meant to be made with VR4VET's methodology. The deviations from the methodology will also be explained further in chapter 5.

Finally, as described in section 2.2, the users had difficulties knowing where to go and, at times, where to put the fish. In an effort to make the application in this project more user-friendly, the gestalt principles were consulted when making design choices. The gestalt principles are described in section 2.1.9. It was the interaction design expert that participated in the user test described in section 6.1.5 that suggested the use of these principles.

### 4.3 Information Gathering

Before the development of the application started, information was gathered on the task that would be simulated in the application. In the research project done prior to this master's project, welfare inspection of fish in an aquaculture was identified as a good task for learning about fish welfare (Baugerud, 2022). That project also tested the latest blue sector application created by IMTEL, and found potential points of improvements, which are described in section 2.2.

The information gathering done during this project was performed largely during a visit to Måsøval AS on the 14th of February. Måsøval is a fish farm on Frøya. During the visit, a tour was given of the facilities. The employees were also questioned about how they performed welfare inspection. More information was also gathered later in the project through a digital meeting with one of the employees at Måsøval.

### 4.4 Requirements

The goal of the application is to teach its users about fish welfare. As described in section 2.2, practical training was identified as an area that could use solutions from digital tools. It was also found that the tested application had some room for improvement. Namely, users had difficulties knowing where to go and where the different components of the tasks were, they had difficulties handling the fish, and they struggled with lack of feedback and instructions. All this knowledge acquired from the research project must be considered when creating the requirements.

From the theory described in chapter 2.1, important aspects for learning in IVR were presented. The CAMIL describes what technological, affective and cognitive factors are important for learning. Bloom's taxonomy also breaks down the different types of learning, both cognitive and affective, and the gestalt principles describes principles that can be used to improve the user experience.

Chapter 3 describes four applications related to learning in IVR, however, as shown in table 3.1 they lack some functionality that should be present in an IVR application about fish welfare.

Through information gathering done in this project, described in section 4.3, information on how fish welfare inspection is performed on a fish farm has been gathered. This information will be essential when designing the application.

Taking all that has been described so far in this section into consideration, the following requirements for the application were made:

**R1: The environment should simulate a realistic fish farm scene.**

**R2: The user should be able to hold and manipulate the fish in a realistic**



way.

**R3: The fish must have realistic, high quality textures to present all the necessary information.**

**R4: The application should be easy to navigate.**

**R5: The user should be given feedback on how they handle the fish, and be scored on how well they are handling it.**

**R6: Instructions on what to do must be easily available to the user.**

**R7: The user must be able to count salmon lice on the fish, rate the fish's gill sickness, and get feedback on their performance.**

**R8: It must be possible to sedate and re-awake the fish.**

**R9: The application must give the user clear feedback on the actions made by the user.**

## 4.5 Testing

All the user tests performed in this project, except for the one described in section 6.1.5, were conducted in Norwegian. All the questions and answers have been translated to English for this thesis.

As mentioned in section 4.2, throughout the development in this project, user tests were performed. The tests that were done during the development phase were semi-structured in nature. The user were given guidance on the controls and an introduction to the application before they tested it. During testing they would be given instructions on what to do by the facilitator. The data gathering was in the form of observations and unstructured conversations after the testing. During these conversations, the tester would often ask one or two pre-planned questions about specific functionality.

At the end of the development phase of the application, Måsøval was visited on Frøya again to perform some final testing with the fish farmers. Guri Kunna high school, also located on Frøya, was also visited on this occasion to test the application with some aquaculture students there. In the days following the test on Frøya, university students were also tested on Dragvoll and Gløshaugen, campuses of NTNU in Trondheim.

The user tests with the aquaculture students were performed in a classroom. As there were two facilitators, two user tests were performed at the same time. The aquaculture students would wait outside the classroom for their turn, as not to distract those currently performing the tests. During the tests, users would get a standard introduction to the application, which covered how to use the equipment and what the application was about. During the tests, the users were observed, and afterward they answered a questionnaire. The first questions in the questionnaire

were background questions (age, experience and gender). The users were then asked the standard system usability scale (SUS) questions. SUS is a quick method of measuring the usability of a system, and consist of ten questions using the five-point likert scale that can be calculated into a single score (Brooke, 1995). Using the score, a grade can be calculated that can indicate the usability of the system. The grading scale can be seen in table 4.2. The aquaculture students were then asked questions categorized into six different domains: Discomfort, enjoyment, value, perceived learning, self-efficacy, organization value, affective, and realism. Though many of those categories could fall under the affective domain, the statement the users were asked to respond to in the affective domain, "I tried to handle the fish respectfully", does not fall under any of the other categories. These questions also used the five-point likert scale, and were inspired by a research paper from 2022. This paper also investigates the use of IVR for training, and is written by experts in the field, which is why it was decided to base the questions of this paper (Baceviciute *et al.*, 2022). Finally, the aquaculture students were asked three questions that they could respond to with text. The questions were "How was it to handle the fish?", "How was it to count lice?", and "How was it to look for sickness on the gills?". These questions were meant to generate qualitative data, without performing a full interview. They were also purposefully made narrow and focused on the most important aspects of the application, as more open questions could lead to the users giving shorter and less detailed answers.

With the university students, user tests were performed either at IMTEL's VR lab at Dragvoll, or at an office on Gløshaugen. These tests were performed over multiple days, and never with multiple users at a time, so distractions were not an issue. Apart from the locale, these tests were performed exactly the same as with the aquaculture students, and they answered the same questionnaire.

The user tests with the fish farmers were performed at Måsøval fish farm. these tests were performed in a storage room at Måsøval's locales. The storage room was chosen because it provided the largest amount of space. Similar to the testing with the aquaculture students, two tests were performed at a time with two facilitators, while the users not testing were waiting in the break room. The fish farmers tested the application in the same way the two other user groups tested it, but they answered a different questionnaire. This questionnaire only contained the background questions and the SUS questions. The fish farmers did, however, participate in an interview after testing the application. The interview was conducted in the break room at Måsøval. In the interview, the fish farmers were asked what they thought of the application, if anything was illogical, if anything should be improved, and if the application could be used as a learning tool. The interview had to be kept brief, as it was performed in the lunch break of the fish farmers.

SUS score	Grade	Adjective rating
> 80.3	A	Excellent
68 - 80.3	B	Good
68	C	Okay
51 - 68	D	Poor
< 51	F	Awful

**Table 4.2:** What grade can be given to an application based on SUS score (T, 2017).

### 4.5.1 User Groups

There were four user groups that participated in the testing of the application during this project. They are fish farmers, aquaculture students, university students and interaction design experts. The following sections will describe the different groups and their involvement in the project.

#### Fish farmers

As previously mentioned, fish farmers participated in the final testing of this application. It was also mentioned in section 4.3 that they were used to gather information on the task that was simulated in the application. The fish farmers are professionals in the task the application simulates, which makes them a valuable source of data, not only because they are most familiar with the task, but because this thesis is exploring whether an IVR application can be used to train professionals in fish welfare. This makes them a target group.

#### Aquaculture Students

Aquaculture students are another target group. They are not professionals, but have some experience and knowledge of fish welfare from their education, and could therefore benefit from training with the application. This makes them a prime target for the application, as they are not fully trained yet. As was mentioned in section 4.5, this group participated in the final testing. They did also participate in a digital demonstration of the application during its development and gave feedback on it. This was done because physical user tests were difficult to arrange given the distance between Trondheim and Frøya, the fact that the user group are full time students, and the limited resources available for this project.

#### University Students

The university students that participated in this project studied computer technology, informatics, Electronics Systems Design and Innovation, and psychology. They had therefore very limited knowledge of the aquaculture industry and fish welfare. As this thesis is exploring how an IVR application about fish welfare can

raise awareness among non-professionals, this user group is also a target group. As stated in section 4.5 This user group participated in the final testing. They were also one of the primary participants in the testing done during development, as they are readily available at NTNU Dragvoll and Gløshaugen.

### **Interaction Design Experts**

As opposed to the other user groups described, this user group is not a target group. They did, however, provide much valuable feedback. Interaction design experts were only involved during the development phase of the application.

### **4.5.2 Quantitative Data**

During the final testing, quantitative data was gathered from the three user groups tested, namely fish farmers, aquaculture students and university students. However, as mentioned in section 4.5, the fish farmers were asked the standard SUS questions and then interviewed. Only the SUS questions can be used for quantitative data analysis for the fish farmers. Mentioned in the same section, the other two user groups were given additional questions that used the five-point likert scale. These questions are the primary source of the quantitative data that can be analyzed in this project.

Due to the difference between the background of the three user groups, the quantitative data gathered for them were kept separate. When analyzing the data, this makes it easier to identify trends within the different user groups, but it greatly decreases the number of data points that can be used for the separate analyses. This makes it difficult to rely on this analysis alone, which makes the qualitative data gathered in this project more important.

### **4.5.3 Qualitative Data**

Qualitative data was also gathered from the fish farmers, aquaculture students and university students during the final testing. For the fish farmers, this was in the form of an interview with four fish farmers. For the other two user groups, it was in the form of three free text questions in the questionnaire. All the users were also observed during testing.

Thematic analysis was performed on the qualitative data, which is a common way of analyzing this type of data. This involves finding attributes in the data and assigning them codes. These codes are then used to identify and create themes. The themes can tell a narrative about the data collected. (*Tematisk Analyse* 2023)

### **4.5.4 Ethical concerns**

During all the testing done in this project, sensitive information was only gathered once, which was during the interview with the four fish farmers. This interview

was recorded, and all the participants signed a consent form, which can be found in appendix A. This master project is approved by the Norwegian Center for Research Data (NSD).



## Chapter 5

# Implementation

A demonstration of the video can be seen at <https://www.youtube.com/watch?v=MrBAMEMAfH0>.

### 5.1 Application overview

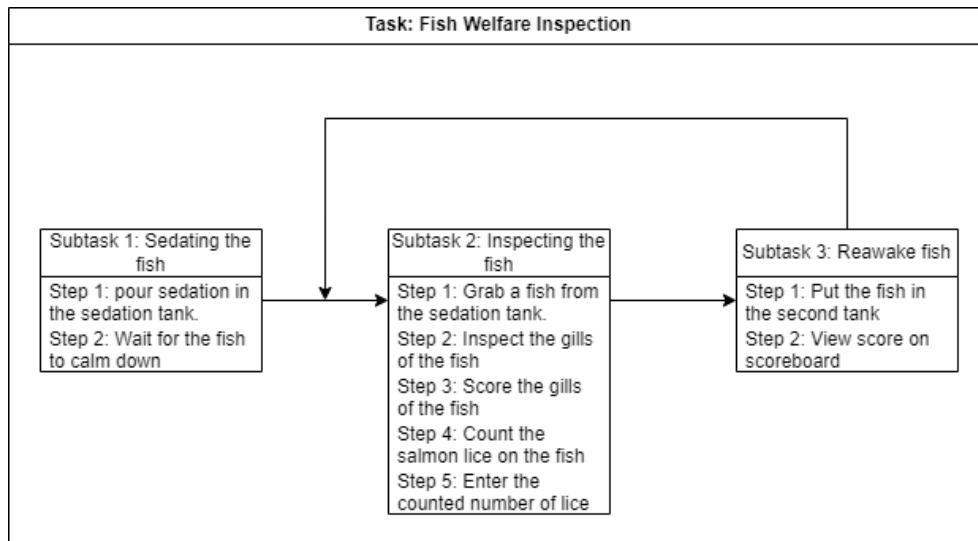
The IVR application was created in the game engine Unity (*Unity 2023*), and the scripts for the varying game objects in the application are written in C#. It is developed for the Meta Quest 2 VR headset (*Meta Quest 2 2023*). However, due to the high level of detail on the fish models described in section 5.2, the application runs best from a computer with better specs, with the HMD connected to it.



**Figure 5.1:** Meta Quest 2: The VR headset used in this project (*Meta Quest 2 2023*).

The application simulates a welfare inspection task from the Måsøval fish farm. Måsøval was selected because IMTEL had a collaboration with them, so acquiring

knowledge on the task to be simulated would be made easier. The task involves first sedating the fish that will be inspected, then inspecting each fish individually. This involves counting salmon lice on the fish and looking at its gills for any sickness. Finally, the fish must be put in the reawakening tank, where they will wake up again. This task was broken into subtasks and steps using the VR4VET methodology, and the flow of the task can be seen in figure 5.2. The locations for the different subtask are placed in a straight line, in an effort to make the task more linear to avoid any confusion with where to go, which was an issue with the previous blue sector application, described in section 2.2.



**Figure 5.2:** The flow of the fish welfare inspection task simulated in the application. Subtasks 2 and 3 are repeated for each fish.

## 5.2 The fish

The focal point of this application are the fish, so a lot of effort was put into trying to make them look and behave realistically. Using Unity's rag-doll system, the fish was made to be entirely limp when out of water to give it a more realistic feel than if it was entirely stiff. When in water, it will also swim around and play a procedural animation, made with the animation rigging package (*Animation Rigging* 2023). When the fish is limp, it will take damage if it hits another object too hard, so the user must be careful when handling it. When taking damage, the fish will play a sound of a fish being slapped against a surface to communicate that it took damage. For the rag-doll physics and swim animation to work properly the fish models need to have a rigging, which basically means they need a skeleton. Otherwise, the fish would be entirely stiff. Each bone has a script that controls the behavior of the bone. The fish itself also has a script that controls its behavior, as well as coordinating the behavior of all its bones.



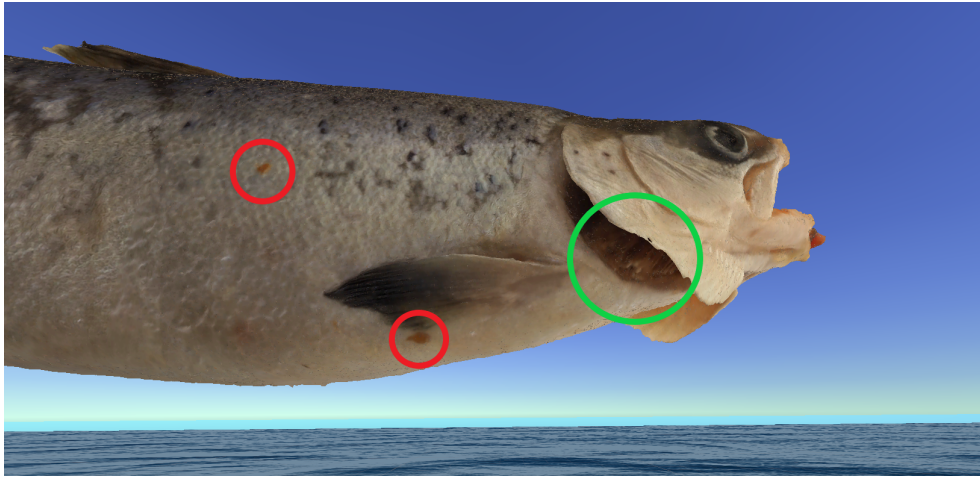


Figure 5.3: A screenshot of a rag-doll fish being held in the user's hands.

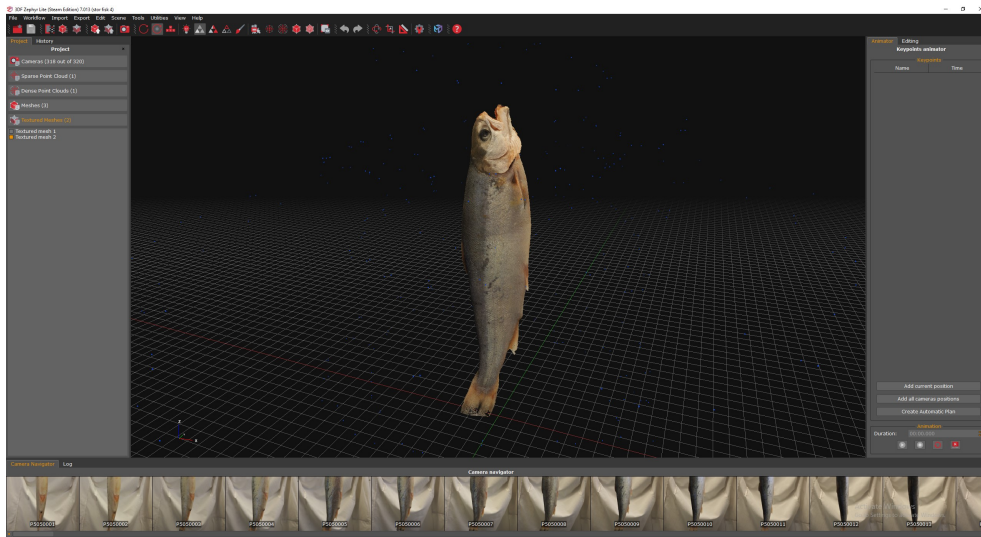
### 5.2.1 Creating the Fish Models

Rigging can not be added directly in Unity, it must already be a part of the model when it is imported into the Unity project. The models were therefore imported to the 3D modelling software Blender (Foundation, 2023), where the rigging (called armature in Blender) was added, and then exported to Unity.

Before rigging could be added to the models, though, the models needed to be created in the first place. All the fish models that were used in this project are original models. They were made using a technique called photogrammetry, which is a method for creating 3D models from overlapping photographs (Autodesk 2023). This was done by hanging dead salmon from the roof and taking photos of it from every angle with a camera. The photos were then fed into a program called 3DF Zephyr, which created a 3D model from the photos (3DF Zephyr 2023). The dead salmon were acquired from NTNU Sealab, and they were also photographed at Sealab. Photogrammetry was used to create fish models with a high level of detail, which is necessary to see details like salmon lice and sickness on the gills. Figure 5.4 shows examples of details on the fish models.



**Figure 5.4:** The red circles highlight lice on the fish model, and the green circle highlights white spots and discoloration on the gills, indicating gill sickness.

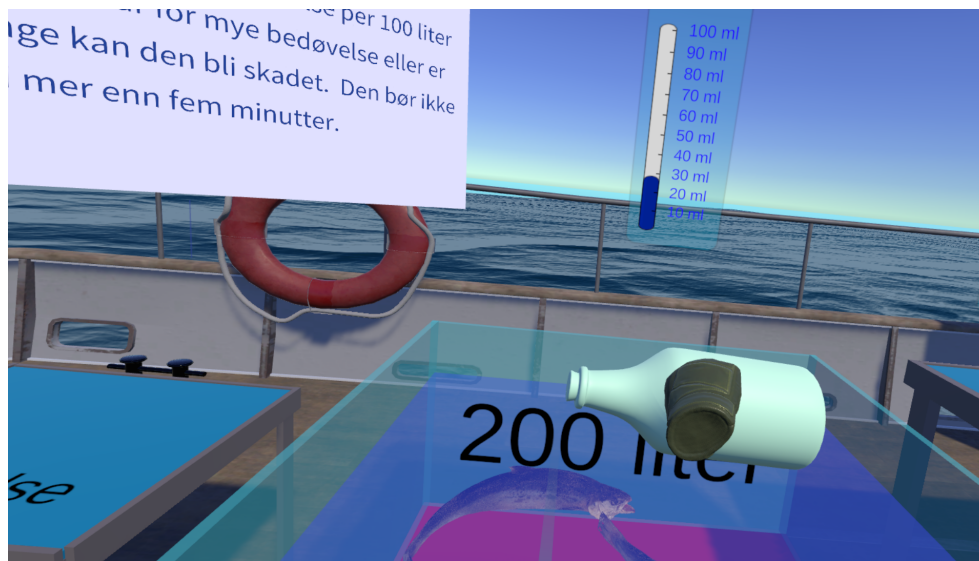


**Figure 5.5:** A screenshot from 3DF Zephyr of one of the fish models created.

### 5.3 Sedation

When fish farmers inspect the fish in real life, they sedate it first, in order not to damage the fish during the inspection. It was therefore important to implement this into the application, and it became the first subtask. Next to the sedation tank is a bottle of sedation that the user can pour into the tank. A gauge above the tank displays how much sedation has been added. It is important not to add too little or too much sedation, which the user is instructed on, because too much can damage the fish, and too little can cause the fish to wake up too early, which also can damage it. In the application, the tank has a script with a float number indicating

the amount of sedation in the water. All fish inside a tank with sedation will have their level of sedation increasing at a set rate multiplied by the sedation level of the tank. The fish will become calmer and calmer proportional to its sedation level, and will eventually stay entirely still when it is ready to be taken out of the tank. If a fish is out of water without being fully sedated, it has a chance of taking damage, and if it is sedated for more than five minutes (or less if too much sedation is added to the tank) it will start to take damage. Unlike when the fish takes damage from hitting something too hard, it will not make any sound when taking damage related to sedation.



**Figure 5.6:** A screenshot from the application, showing sedation being poured into the tank.

## 5.4 Inspection

Inspection is the second subtask of the welfare inspection task. In this task, the user must inspect the fish and find the number of lice on it and rate the severity of its gill sickness. The user must interact with a graphical user interface (GUI) to enter the number of lice and the severity of gill sickness. The GUI is intentionally not placed above the sedation tank, but over a table next to it. This is in an effort to use the principle of proximity, described in section 2.1.9, to make the user automatically understand that they can put the fish on the table to make the inspection easier. This also moves the user closer to the next stage of the task, which is the final subtask of re-awaking the fish. All the fish use the same rating interface, but it is reset whenever a new fish is grabbed. An empty game object has a manager script that keeps track of what fish is currently selected and what scores the different fish have.

Originally, the number of lice was not entered into the GUI like gill sickness was. The user had a laser pointer from their finger when pointing at the fish. They would have to point the laser at a louse and click it to mark it as counted. However, late in development, this system was found to be too cumbersome and was replaced with the current system.



**Figure 5.7:** A screenshot from the application, showing the interface for inspecting the fish.

## 5.5 Re-awakening the fish

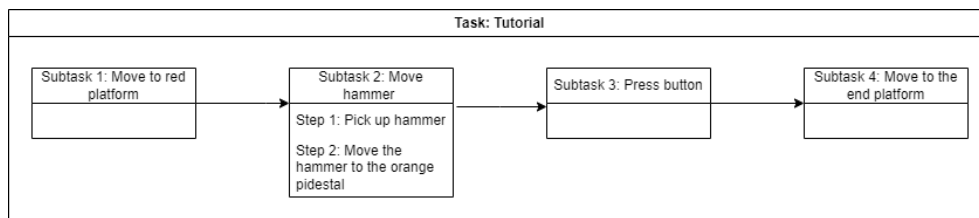
The final subtask of the task is to get the inspected fish into the re-awakening tank. If a fish is in a tank with a sedation level of zero, the sedation level of the fish will decrease. This way, the fish will slowly wake up again when put in the re-awakening tank. Behind the re-awakening tank, a scoreboard can easily be seen by the user. When a fish is put in the re-awakening tank, their stats will appear on the scoreboard. This includes what severity of gill sickness they were given compared to what it actually was, the same for number of lice, a handling score, and finally, a total score, that combines the score from the three prior scores. Each of the three scores can give a maximum of 10 points, so the final score will be between zero and 30. The handling score is based on how much damage the fish has taken.



**Figure 5.8:** A screenshot from the application, showing the scoreboard and the re-awakening tank.

## 5.6 Tutorial

In addition to the fish welfare inspection task, there is a tutorial task at the beginning of the application. This application is meant to teach the user the controls of the application. Similar to the welfare inspection task, the different locations in this task are placed in a linear order to avoid any confusion. Like the welfare inspection task, this task was designed using the VR4VET method. In the task the user is first asked to move to a platform, then move a hammer from one pedestal to another, then press a button, and finally, move to the end platform that will teleport the user directly to the start of the welfare inspection task. Figure 5.9 shows the flow of the tutorial task.



**Figure 5.9:** The flow of the tutorial task simulated in the application.

## 5.7 3D Models and Other Assets

The 3D models and other assets used in the IVR application can be put into one out of three categories. The First category is assets created for this project. This

category includes the fish models that were described in section 5.2. It also includes the fish tanks and the scoreboard, but these were simply made with the rudimentary 3D modelling tools in Unity. They can be seen in figure 5.8. They were originally planned to be updated to look more realistic, but after the user test described in section 6.1.5, it was decided to keep the models as they were. This was in an effort to make the application more user-friendly by utilizing the principle of similarity (MacNamara, 2017). By having objects that are important to the tasks in the application be in bright primary and secondary colors, the user's eyes may be drawn to them, making it easier to navigate the tasks.

The second category is third party models acquired specifically for this project. This includes the boat (*Fishing boat - Unity Asset Store 2023*) and the sedation bottle (*Growler jug - Free3D 2023*). Both of them were modified somewhat to fit the needs of the application. These models helped the environment look more realistic and were too complicated to be made from scratch.



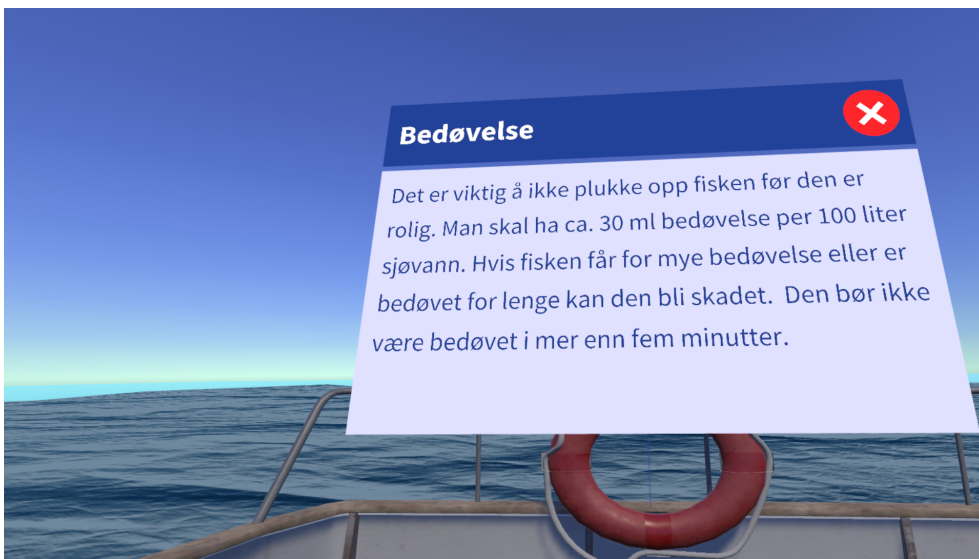
**Figure 5.10:** The boat model purchased for this project (*Fishing boat - Unity Asset Store 2023*).

The third and final category is assets and models from VR4VET. VR4VET has a number of assets created by the team working on the VR4VET project. Among these is the tooltip, which was the primary medium used to provide the user with information and instructions in the application. VR4VET also has a tablet asset that can be used to display information about tasks, and is the primary way of showing information on skills. However, due to issues with implementing the tablet into the application it ended up not being included, which subsequently also means skills, as they are described in section 4.2, are not included either. VR4VET also includes the BNG framework, which is a framework that includes a plethora of assets, models and scripts for creating IVR applications in Unity (*Bearded Ninja Games 2023*). The player rig, which is what the user controls when using the application, the hammer, as well as functionality for grabbing objects are from the



**Figure 5.11:** The bottle model used for this project (*Growler jug - Free3D 2023*).

BNG framework. Using this framework greatly reduced the amount of functionality that had to be manually implemented for this project.



**Figure 5.12:** A screenshot of one of the tooltips in the application.

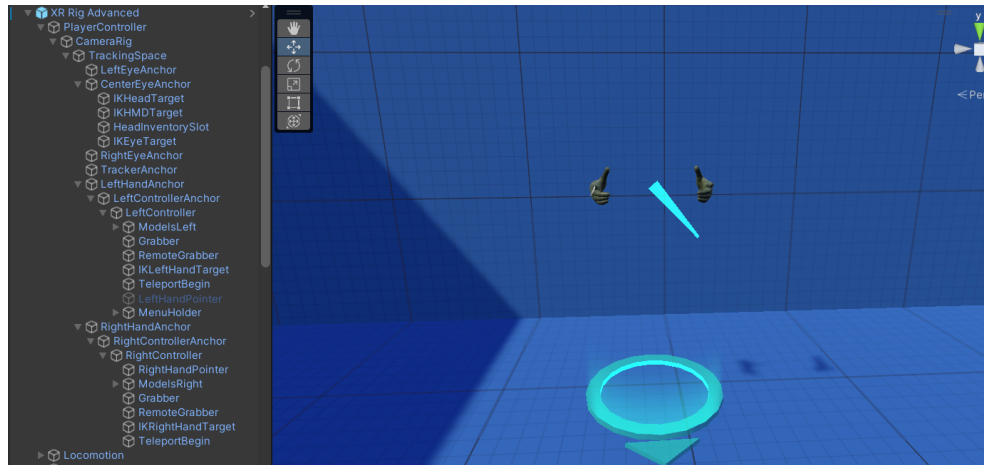


Figure 5.13: A screenshot of the player rig in the Unity scene.

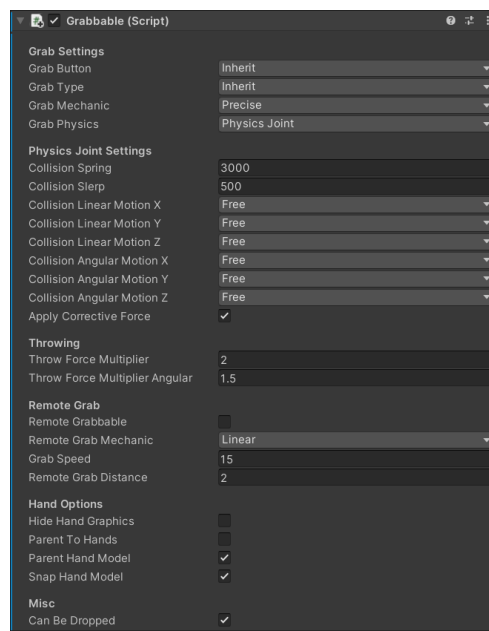


Figure 5.14: A screenshot of the grabbable component used for grab functionality in the application.



## Chapter 6

# Evaluation Results

This chapter presents all the data collected in this project, and is divided into three main sections. The first section will present all the data collected during the development of the application, the second section covers the quantitative data collected during the final testing of the application, and the third section covers the qualitative data collected during the final testing.

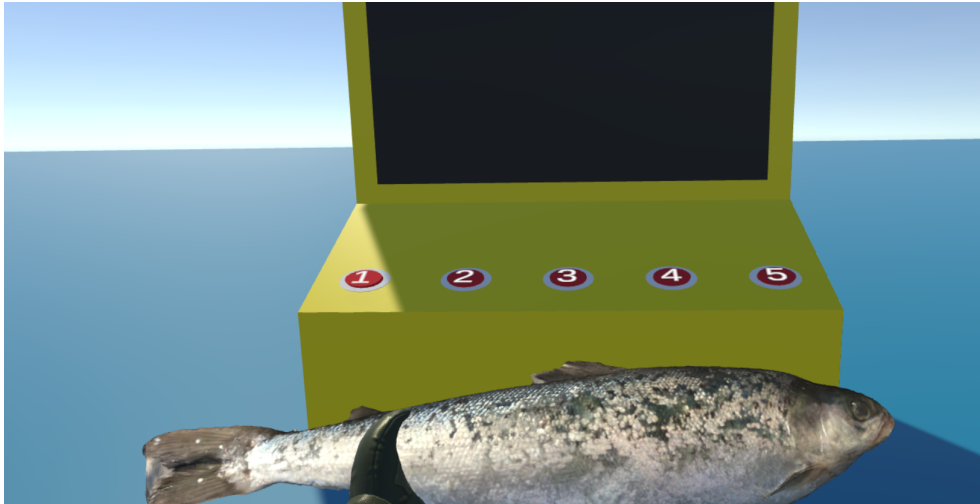
### 6.1 Testing during development

The iterative nature of the application made the testing during development very important. The feedback collected helped stake out the course for the application's further development. The testing during this phase of the project was less formal than that done during the final testing, and consist of observations and unstructured conversations with the users during and after testing.

#### 6.1.1 User Test With Interaction Design Experts 07.03.23

On the 7th of March, a delegation from Slovenia visited the VR-lab on Dragvoll. Some of them tested the earliest version of the application. The main purpose of this testing was to test usability and to get feedback from interaction design experts, which some of the delegates were. The methods used for testing were observation and free form discussion with the users after they tried the application. The users were asked about what they enjoyed in the application and if anything in it confused them.

In the version of the application that was tested, it was two fish models on a pedestal that the users were asked to rank the welfare of. This was done at a large station to the left of the fish models with five buttons on it. It was also a tank that the fish models would have to be put into to see the results of its rating. Figure 6.1 shows a screenshot of the application. As can be seen, the environment was very simple and not realistic.



**Figure 6.1:** A screenshot from the version of the application tested on the seventh of March. It shows a user holding a fish and the station used for rating it.

Most of the comments and feedback gathered throughout the testing fell into one of four general categories. The first category is the rating of the health of the fish. None of the users were familiar with fish welfare and had therefore no way of knowing how to rate the fish. The application gives no information about what to look for on the fish, nor what constitutes the different ratings. Many of the users also pointed out this fact, and recommend that there should be instructions in the final application in what to look for.

The second category is the tablet. For many of the users, the tablet and the belt it is attached to got in the way during testing. Especially if they needed to pick a fish up from the ground, the belt and tablet got in the way. It was also noted by some of the users that they felt the belt was awkwardly placed. Some of the users also felt the user interface of the tablet was awkward. Using pages instead of a scroll bar was mentioned as one improvement that could be made to the tablet. Another was adding a handle to the tablet so that users would not block some of the screen when holding the tablet. Multiple users also said that information on the tasks should be given to the user more directly in the application, and not through the tablet.

Some of the users also had problems with the controls and movement in the application. Some users felt continuous movement would be better than teleportation. Others thought there should be a button for teleportation on both controllers. One user suggested using the Quest 2's hand tracking controls instead of the index controllers, and another suggested using only one index controller. This category is the one where the users had the most varying suggestions.

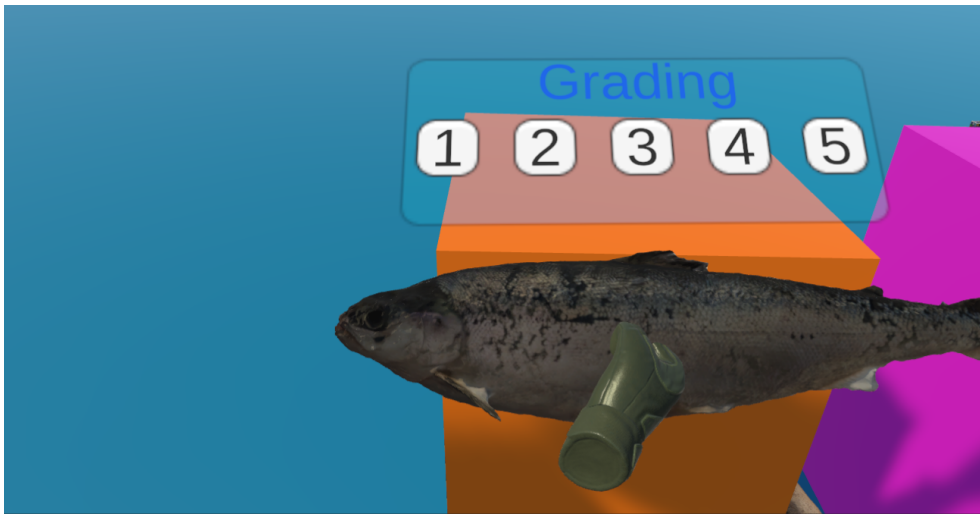
The final category of feedback is the environment and layout of the application. It was noted by multiple users that the environment was not realistic and did not

lend itself well to an IVR application. Some users also found the layout of the application cumbersome. Having to turn around to put the fish in the tank and then turn back around to see the result did not seem to be intuitive for many of the users. A user suggested that instead of clicking a button to give the fish a rating, it could be put into a tank associated with the score one wanted to give it. This would eliminate one of the steps in the process.

### 6.1.2 User Test With Students 23.03.23

On the 23rd of March, two master students tested the application. It was similar to the version tested on the 7th, but the way users rated the fish were moved from the yellow panel to an interface over the fish. One of the master students studied informatics and the other electronics systems design and innovation. The same testing methods were used on this occasion as on the seventh of March, described in section 6.1.1

In this version of the application, the way in which the user gives the fish a score on its health had been updated. Instead of the user having to click a button on a station, a hologram-like interface would show up above the fish, whenever it was grabbed by the user, that would be used to rate the fish.



**Figure 6.2:** A screenshot from the version of the application tested on the 23rd of March. It shows a fish with the interface for rating it above.

The new interface for rating the fish seemed to work better. When grabbing the fish, the users immediately seemed to understand what they had to do to give the fish a score. Although the users no longer had to press a physical button to give a rating, it was still noted by the users that it was cumbersome having to turn around to see the result on the screen after putting the fish in the tank. Like in the previous user tests, these users also had issues with the tablet and belt getting in the way when picking items up from the ground.

### **6.1.3 Demonstration for aquaculture class 14.04.23**

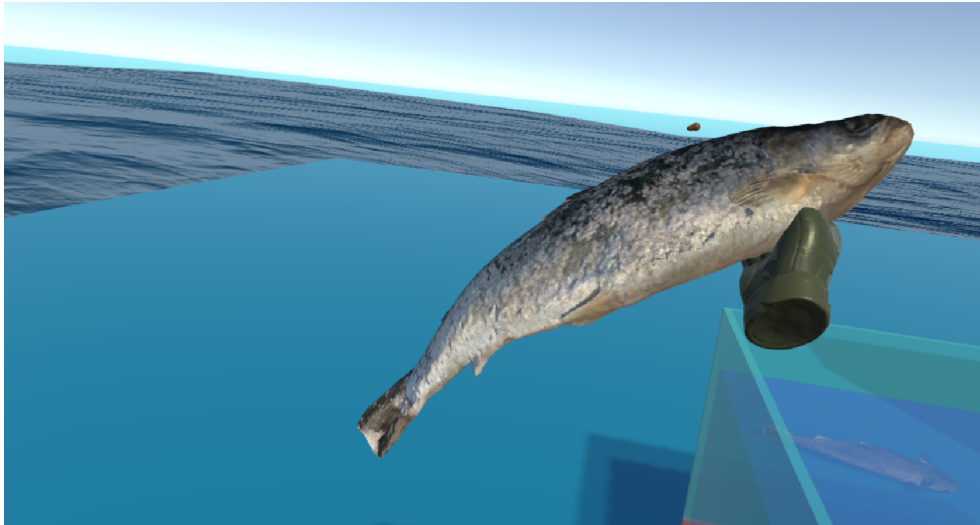
On the 14th of April, a digital meeting was held with an aquaculture class from Guri Kunna high school. During the meeting, a demonstration was performed of the application to the class and its teacher. The purpose of the demonstration was to make sure that the tasks were depicted accurately in the application. As the version of the application that was demonstrated was the same as the one tested on the 23rd of March, the demonstration was accompanied by a description of what the final application was planned to look like.

The teacher confirmed that what they were shown and told was mostly accurate to the task done in real life. The one exception was the handling of the fish. They stressed the importance of handling the fish with respect and care, as not to damage it in any way. Functionality for evaluating the level of care taken when handling the fish was therefore made a requirement for the application.

### **6.1.4 User Test with VR developer 03.05.23**

On the third of May, a VR developer tested some of the functionality in the application. In this version of the application, rag doll physics had been added to the fish in the application, as well as behavior when in water. The layout of the objects in the application was also changed, the fish would start in a tank of water, the interface for rating the health of the fish was now specifically for the health of the gills, and functionality for counting salmon lice had been added. The lice on the fish were work in progress though, and were represented by simple 3D models on the fish, because no 3D model with fish lice on it had been created yet. As opposed to previous user tests, on this occasion the user was specifically asked about their experience in interacting with the fish.

The user felt that the rag doll physics mostly made the fish feel more realistic. They did note that lice felt unrealistic, because they were not properly attached to the rest of the fish. The user also felt that the interface for rating the gills was in the way when looking at the fish. The problem with the lice was already known, but the issue with the rating interface was a new one, introduced with the addition of the rag doll physics.



**Figure 6.3:** A screenshot from the version of the application tested on the third of April. It shows a user holding a fish with rag-doll physics.

### 6.1.5 User Test With Interaction Design Expert 09.05.23

On the ninth of May, an interaction design expert visiting the VR lab at Dragvoll participated in a user test. Unfortunately, due to some technical issues, they were not able to test all the features in the latest version of the application. A bug hindered users from interacting with the rating interface. Nevertheless, the user was asked to evaluate the health of the fish verbally, in addition to picking it up and moving it from the start tank to the end tank. Although the functionality in this version was limited by the bug, the environment was updated to be more realistic. The tasks in the application were done on a jetty out on the sea. As with previous tests, observations were made during the testing, but it was followed up with a semi structured interview afterward.

the user was generally very positive to the application. They felt very immersed in the application, citing good feedback from the VR-system (meaning the HMD and controllers), and an almost lifelike environment. The user also felt picking up the fish felt realistic, stating that it "felt like picking up something that was alive", and that "it had a good cognitive feel". finally, he felt the character's shadow gave them a sense of presence. Despite the immersion, they did not feel any motion sickness or other discomfort. Even though the user often has needed time to adjust in other IVR application they have tested, they did not need it in this one. The tasks and instructions given also made the user get in the mindset of the application being about inspection and zoology, not cooking. They said they thought it must be some chemical in the first tank, which is why they must be moved to another tank. This is exactly what is the case in the final version of the application, where sedation is added to the water in the first tank.

Before the user tested the application, they were given an on-boarding, with instructions on how to use the controls and an explanation of the tasks they would perform in the application. In the interview, the user was also asked what they thought about that part. They were very positive to the on-boarding as well. The user thought the instructions were clear and helpful, and they also appreciated that they got to see me set up the equipment that would be used, so they got a better understanding of how it worked.

Finally, when asked if they thought the application would be better by replacing some of the more unrealistic looking objects, he mentioned some aspects of those objects that should not be removed. This included the water tanks and the board showing the results of the inspection. The tanks were planned to be replaced with more realistic opaque tubs, but the user liked that they were transparent, so they could see the fish. They also liked the use of bright primary and secondary colors for the tanks and the score board, as the colors drew their attention to where they needed to look. The user had personal experience with developing an educational IVR application where users were meant to inspect certain bones. After much experimentation with different realistic bone colors for the bones the users were supposed to inspect, they found that a bright red color drew the attention of the users more, which made the learning experience better. They thought of using the red color after learning about the gestalt principles, specifically the principle of similarity, described in section 2.1.9. This is why the user noticed and appreciated the use of colors in this application. The layout also worked well, they felt, because the objects in the application were put in the order that was most natural for a user to use them. The user felt the colors and layout really took advantage of the gestalt principles.

## 6.2 Final testing

The 14th of May was set as the deadline for development of the application, as time would be needed to finish the thesis. There were, however, one alteration made to the application after the testing done on the 15th. The system for counting salmon lice was changed from where users would point at individual lice and mark them with a pointer laser, to users setting a slider to the number of lice found on a fish. This slider was integrated into the same interface used for rating the gills of the fish. This change is explained in section 5.4, and further discussed in section 7.1.2. Beyond that, the application used in the tests described in the rest of this chapter is the final version described in chapter 5.

### 6.2.1 Quantitative Data

The quantitative data presented in this section comes from the questionnaire described in section 4.5, that was based on the questionnaire of a research paper from 2022, investigating the use of IVR for training (Baceviciute *et al.*, 2022).

This section is divided into three subsections, one for each of the different user groups. This is because the three groups are quite different, and as will be seen, gave quite different responses on the questionnaire.

### User Tests With Aqua Culture Students 15.05.23

on the 15th of May, Guri Kunna high school on Frøya was visited to perform user tests with students from a vocational class with focus on aquaculture. In total, nine students participated in the user tests. three of them were women and six were men. All the users were either 16 or 17 with the average age being 16.4.

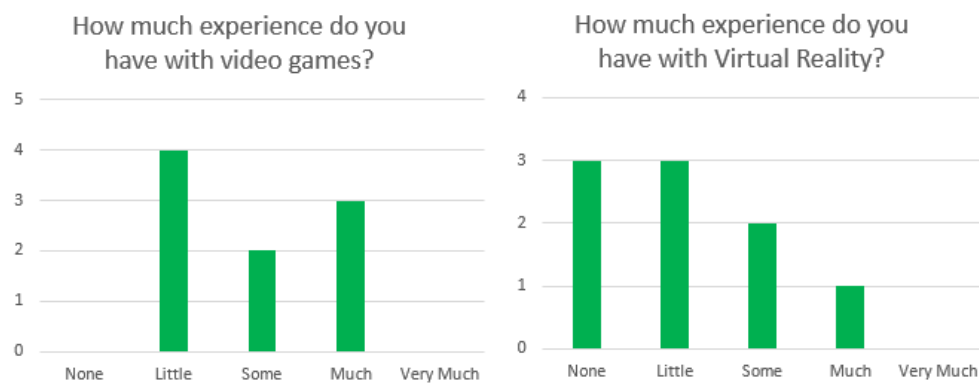


Figure 6.4: The aqua culture students' experience with video games and VR.

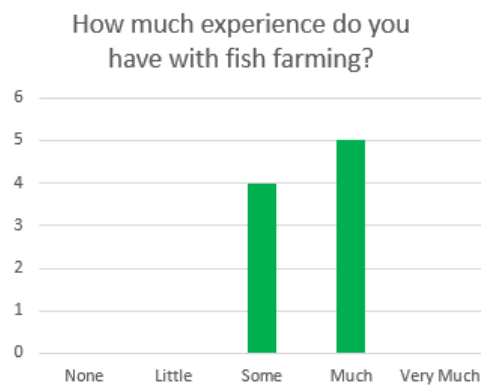


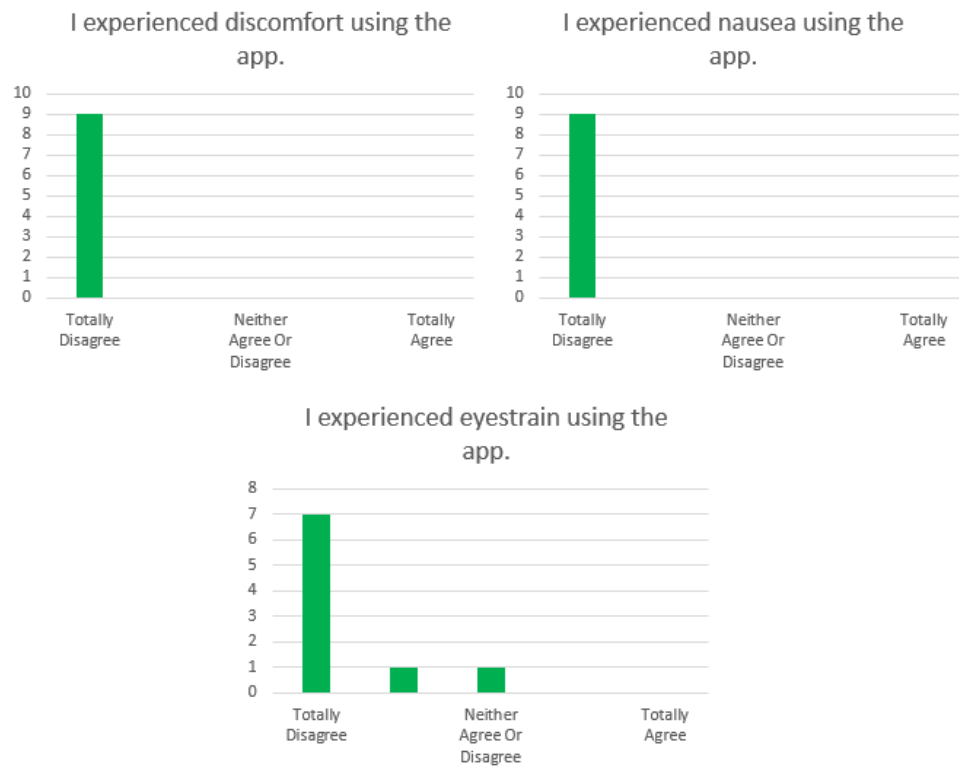
Figure 6.5: The aqua culture students' experience with fish farming.

As can be seen in figure 6.4 the aquaculture students were divided in their experience with video games, with "Little" being the most common response, but a majority responding "Some" or higher. This is more experience than what they had with VR. One third of the users had no experience with VR, and another third had "Little" experience. Their experience with fish farming was the highest, which is to be expected as they study aquaculture. Figure 6.5 shows that 5 users had "Much" experience with fish farming and the rest had "Some".

User ID	SUS score
1	82.5
2	70.0
4	90.0
3	67.5
5	72.5
6	47.5
7	62.5
8	60
9	67.5

**Table 6.1:** The SUS scores given by the aquaculture students.

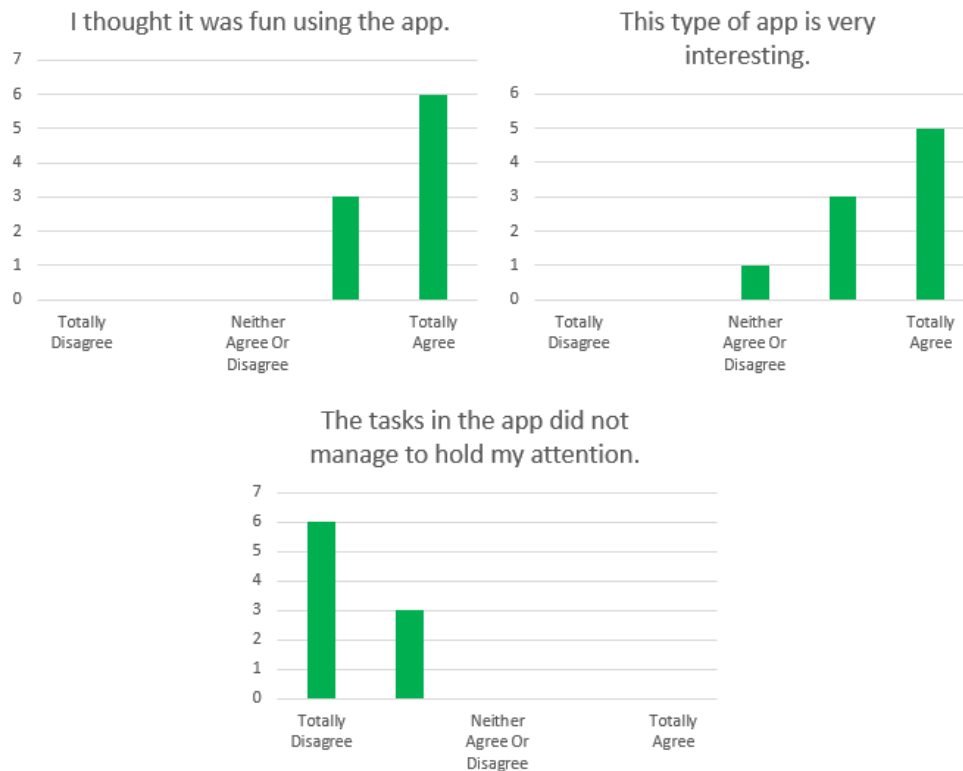
Table 6.1 shows the SUS scores to all the users. The mean SUS score for the users were 68.9, which from table 4.2 gives it a grade of B, Good.



**Figure 6.6:** The aquaculture students' responses to questions about discomfort.

None of the users experienced any significant discomfort during the tests. Figure 6.6 shows that no user felt discomfort or nausea, but two users may have experienced some eyestrain.



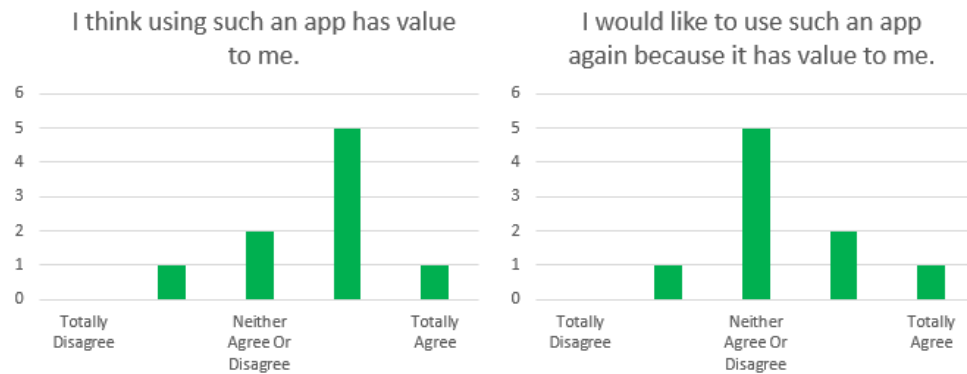


**Figure 6.7:** The aquaculture students' responses to questions in the enjoyment domain.

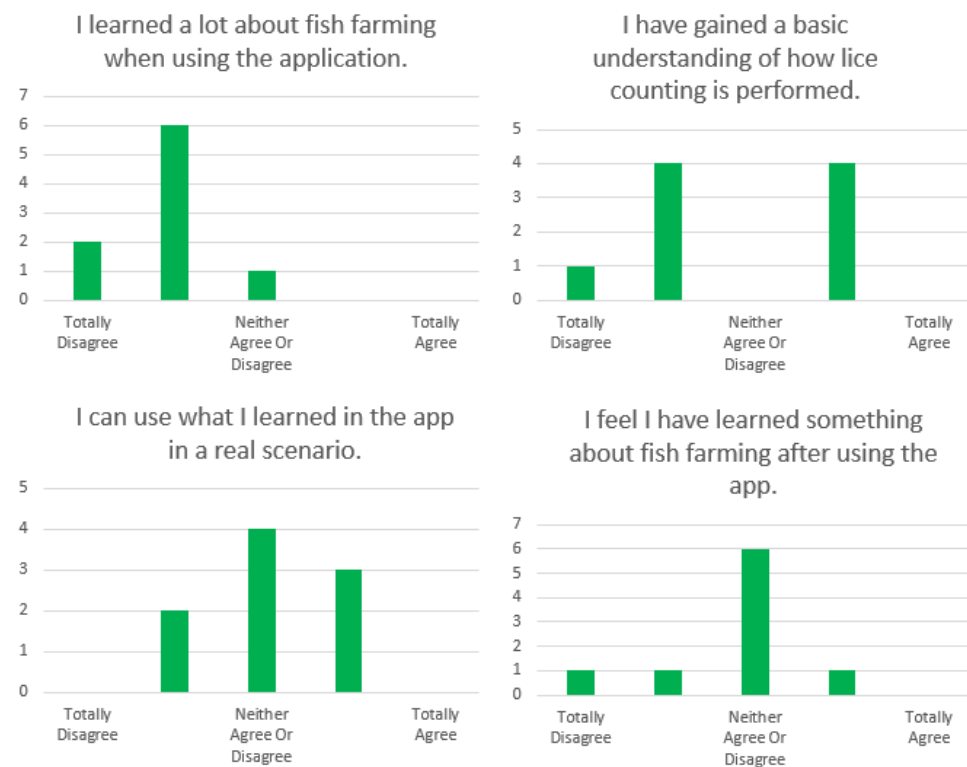
All the users seemed to enjoy using the application, and a user even loudly said "wow, VR is cool" the first time they picked up an item in the application. This observation is also supported by the graphs in figure 6.7, which shows graphs pertaining to questions about enjoyment. Most user found the application fun and interesting, and felt that the application was able to hold their attention.

The users' response to the value of the application was a bit more mixed than their enjoyment of it. The majority of the users believe the application have some value to them, with two thirds giving "I think using such an app has value to me" a 4 or higher, which can be seen in figure 6.8. However, as can also be seen in figure 6.8, when asked if the user would want to use such an app because it has value to them, the responses were less positive. The majority neither agreed nor disagreed, with a couple more giving a positive rather than a negative response.

The four questions asked about perceived learning also gave mixed responses, as can be seen in figure 6.9. The users did not believe they learned a lot about fish farming, but were more uncertain about if they learned something about fish farming, with six users neither disagreeing nor agreeing with "I feel I learned something about fish farming after using the app.". "I have gained a basic under-



**Figure 6.8:** The aquaculture students' responses to questions in the value domain.



**Figure 6.9:** The aquaculture students' responses to questions in the perceived learning domain.

standing of how lice counting is performed." was a particularly divisive question, with four users disagreeing and four users agreeing.

As for self-efficacy, the users seem to be confident in their understanding of the concepts presented in the app, and in their ability to perform the tasks they learned



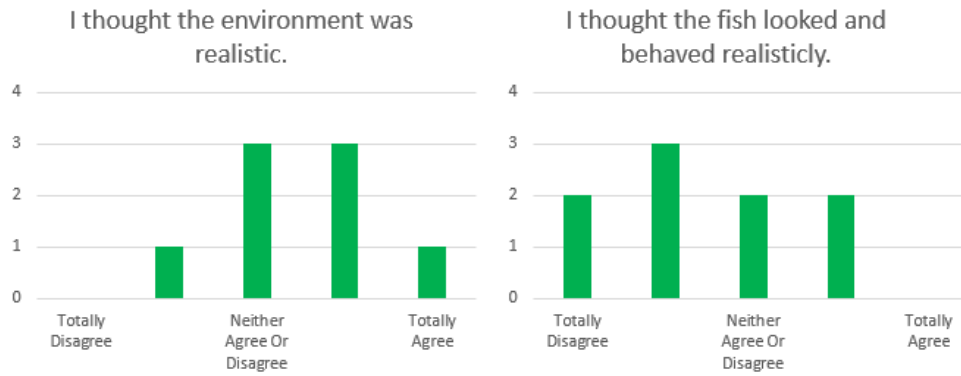
**Figure 6.10:** The aquaculture students' responses to questions in the self-efficacy domain.

in the application. This can be seen in the last two graphs in figure 6.10. It was also observed during testing that most users were able to perform the tasks, and seemed to understand what was going on. On the statement, "I think I could give a good explanation of lice counting to a colleague or fellow student.", however, the users do not seem to be as confident. With the majority of users neither agreeing nor disagreeing, and the rest split between "Agree" and "Disagree".

The two statements in the questionnaire about realism gave fairly different results, with "I thought the environment was realistic" getting a fairly positive response, and "I thought the fish looked and behaved realistically" getting a more negative response. This can be seen in figure 6.11. It was also observed that many of the users had difficulties putting the fish in the position they wanted. The fish would often start shaking if held, and roll back to its original position if the user attempted to rotate it on the table. This is behavior that is not realistic for a fish.

The one question asked about organization value can be seen in figure 6.12. The results for this question is mixed and does not give any clear answers.

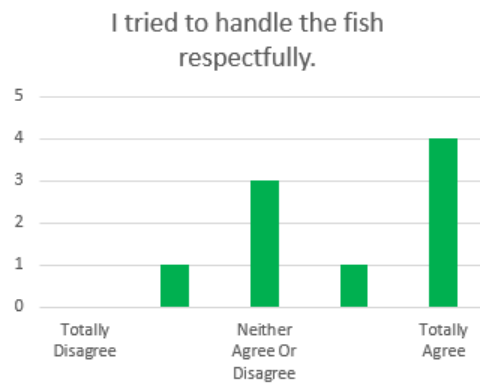
The one question pertaining to the affective domain, which can be seen in figure



**Figure 6.11:** The aquaculture students' responses to questions in the realism domain.



**Figure 6.12:** The aquaculture students' responses to questions in the Organization value domain.

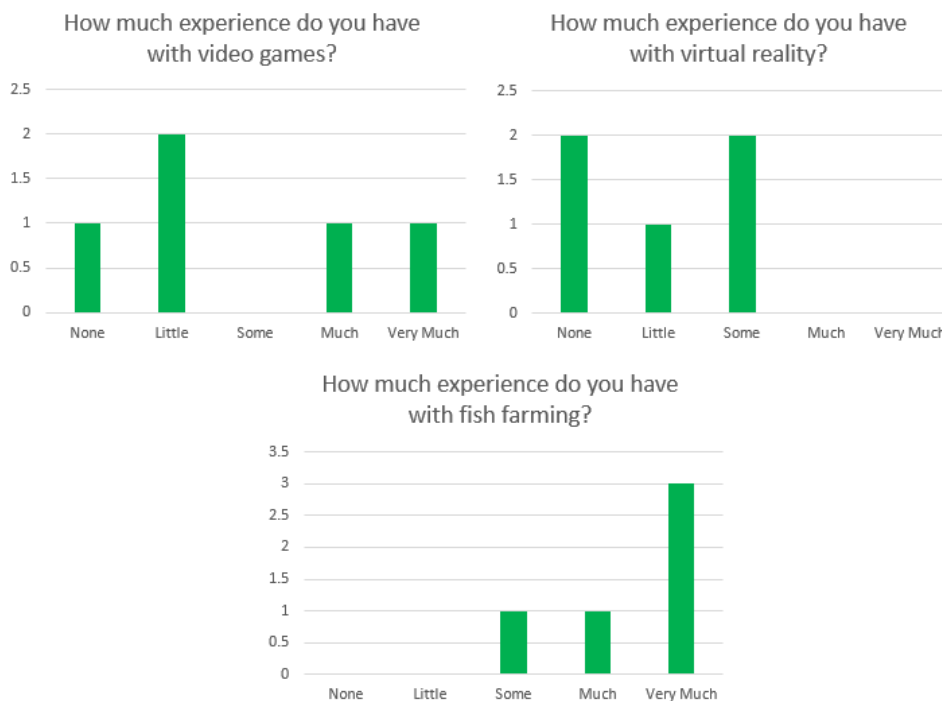


**Figure 6.13:** The aquaculture students' responses to questions in the affective domain.

6.13, gave a clearer answer than the question for the organization value domain. Most users responded with them trying to treat the fish with respect. It was also observed that the users tried to handle the fish carefully. Some users were not careful in the beginning, but once they damaged the fish or realized they were scored on how well they treated the fish, they would try to be more careful.

### User Tests With Fish Farmers 15.05.23

On the 15th of May, Måsøval fish farm was also visited to perform user tests on fish farmers. 5 users participated, all of them men. This user group had the largest variance in age, with the youngest being 31 and the oldest 62. The average age was 40. As mentioned in section 4.5, this user group only answered the background questions and the SUS questions in the questionnaire.



**Figure 6.14:** The fish farmers' experience with video games, VR and fish farming.

From figure 6.14 the fish farmers' responses to questions regarding experience. They are quite split on video game experience, with them either having "Much" or more, or "Little" or less. Similar to the aquaculture students, they had little experience with virtual reality. Out of all the user groups, though, they have the most experience, which makes sense, because they are professional fish farmers.

Table 6.2 shows the SUS scores given by the fish farmers. They had a mean SUS score of 67.5, the lowest of all the user groups. From table 4.2 that gives it a grade of D, Poor.

User ID	SUS score
1	72.5
2	75.0
3	70.0
4	70.0
5	50.0

**Table 6.2:** The SUS scores given by the fish farmers.

### User Tests With University Students

As previously mentioned, a final change was made to the application after the user tests on the 15th of May, changing the lice marking system. After that, user tests were performed on university students. There were 10 user tests performed on university students, with eight of them being men, one woman and one other. The university students answered the same questionnaire as the aquaculture students. The average age of the users was 25 and the mode was 23.



**Figure 6.15:** The university students' experience with video games, VR and fish farming.

Figure 6.15 shows the experience the users have with video games, VR and aqua-

culture. These graphs show that the experience of these users are quite different from that of the aquaculture students. All but one of the users had much or more experience with video games. Their experience with virtual reality is more similar, but still more experienced than the aquaculture students. And, finally, the biggest difference in experience between university and aquaculture students was with fish farming. The majority of aquaculture students had "Much" experience, with the rest having "Some". eight out of ten university students, on the other hand, had no experience with fish farming and two had "Little".

User ID	SUS score
3	70.0
4	75.0
5	90.0
6	77.5
8	72.5
7	92.5
9	85.0
10	60.0
1	45.0
2	70.0

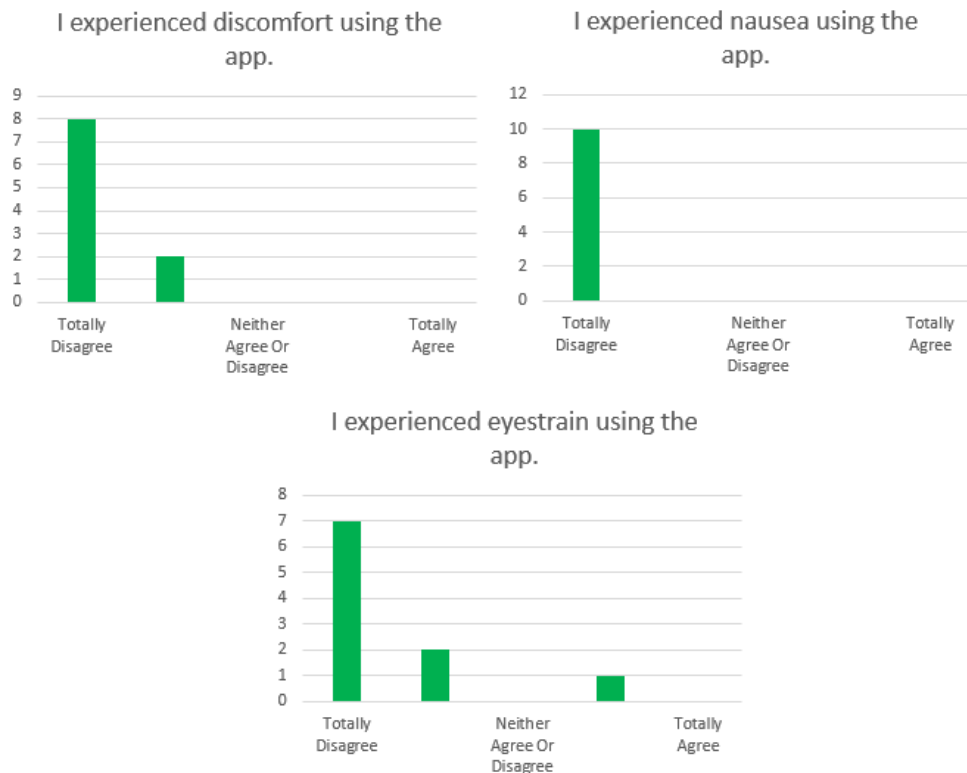
**Table 6.3:** The SUS scores given by the university students.

Table 6.3 shows the SUS scores given by the university students. They had a mean SUS score of 73.75, the highest of all the user groups. From table 4.2 that gives it a grade of B, Good.

Similarly to the aquaculture students, the university students did not experience significant discomfort using the application, as can be seen in figure 6.16. The one notable exception is one user who experienced a some eyestrain.

Figure 6.17 shows questions the users were asked in the enjoyment domain. All the users enjoyed the application, and most users found it interesting and and felt the tasks in it held their attention. This is also similar to the responses of the aquaculture students. However, where all the aquaculture students to some degree agreed that the tasks held their attention, for the university students one neither agreed nor disagreed and one disagreed.

The value domain is one where the university students had pretty different responses from the aquaculture students. Figure 6.18 shows that the majority of users responded with "Disagree" or "Totally disagree" when asked if they thought the application had value to them. When asked if they would use the application again because it had value to them, the responses were similar, but with two users giving a more positive response. This is in contrast with the aquaculture students, where the majority felt the application had value to them, but being a bit more uncertain on if they wanted to use it again.



**Figure 6.16:** The university students' responses to questions about discomfort.

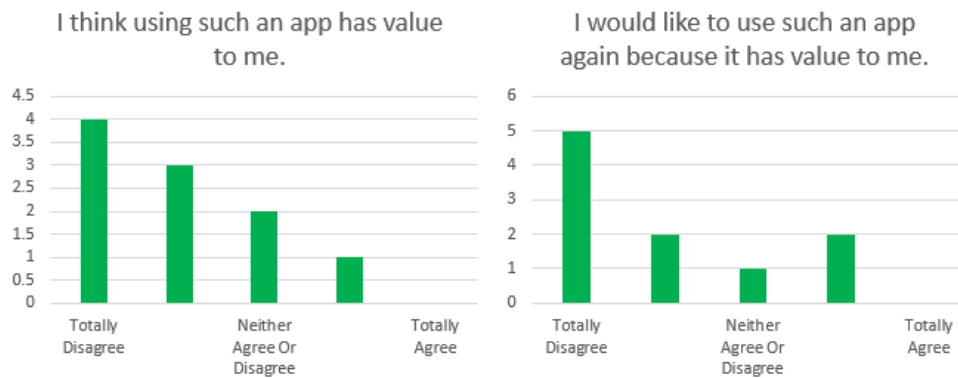
Figure 6.19 shows the answers to questions in the perceived learning domain. This is another domain where the users' responses varied from that of the aquaculture students. The aquaculture students were mostly negative, neutral, or split on questions regarding perceived learning. The university students, though, were largely positive. The question about whether the users felt they had learned a lot about fish farming is the one the users were the least positive to, with only 50 percent agreeing to some degree. They were also a bit split on whether they could use what they learned in a real scenario, with seven being positive, but two responding "Totally disagree" and one with "Disagree". To the other two questions regarding perceived learning, almost all users responded positively.

The users were also mostly positive on questions regarding self-efficacy, as is shown by the graphs in figure 6.20. "I am certain I could perform the tasks I learned in the app." is the most divisive question in this domain. 50 percent agreed to some extent, but the most popular answer was "Neither Agree Or Disagree". These responses also varied somewhat from that of the aquaculture students. Both user groups were mostly confident in their ability to understand the concepts presented in the application, but the aquaculture students were more neutral in their responses to whether they could give a good explanation of lice counting, while the university students were more positive. The aquaculture students were





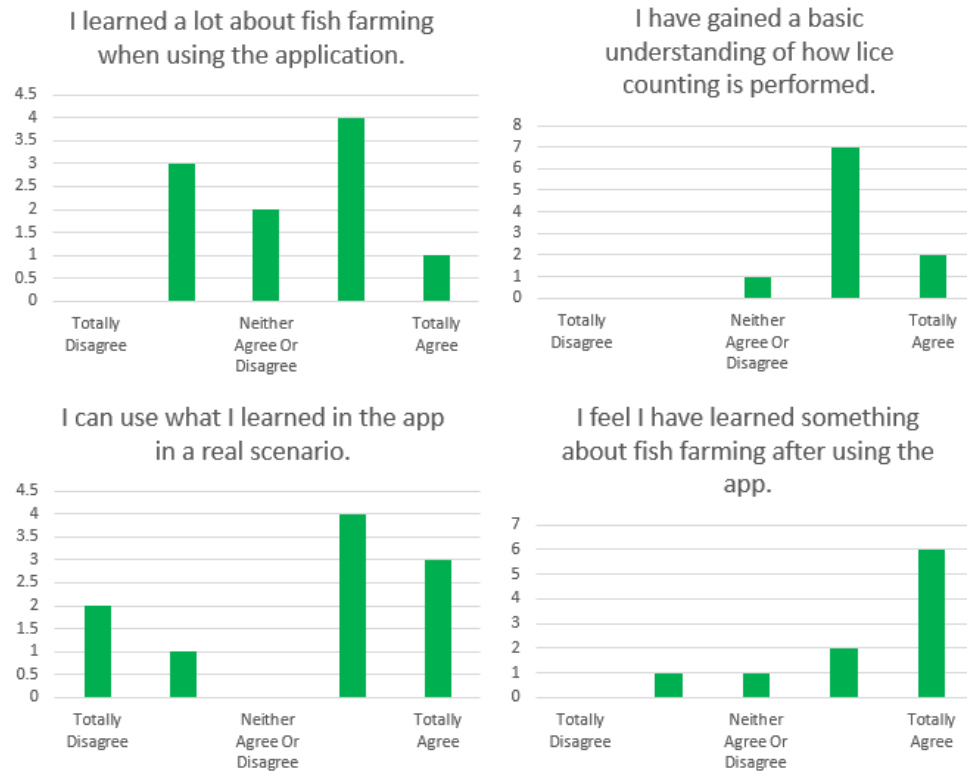
**Figure 6.17:** The university students’ responses to questions in the enjoyment domain.



**Figure 6.18:** The university students’ responses to questions in the value domain.

also more confident in their ability to perform the tasks learned in the application.

Though not uniform in their responses to questions regarding realism, the users largely gave positive responses, as can be seen in figure 6.21. They were more positive than the aquaculture students, as those students largely disagreed to some



**Figure 6.19:** The university students' responses to questions in the perceived learning domain.

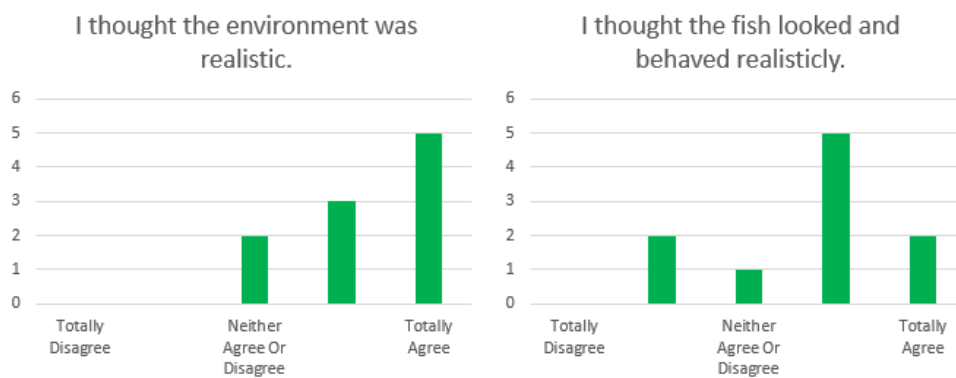
extent that the fish looked and behaved realistically.

Figure 6.22 shows the one question the users were asked in the organization value domain. Half of the users were neutral on whether they had gotten more interested in fish farming. This is similar to the aquaculture students' responses, as their most popular response also was "Neither Agree Or Disagree".

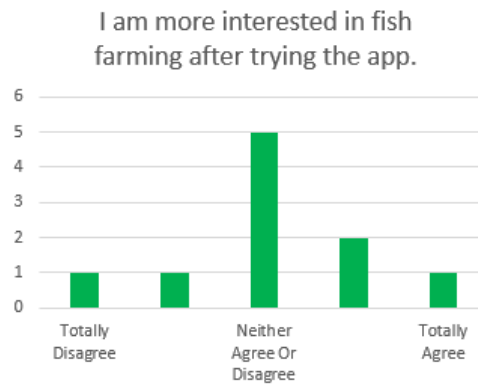
The responses to the stated "I tried to handle the fish respectfully" got a very split response from the users, with "Totally Disagree" and "Totally Agree" being equally popular responses. This is dissimilar to the aquaculture students, which generally agreed more with the statement.



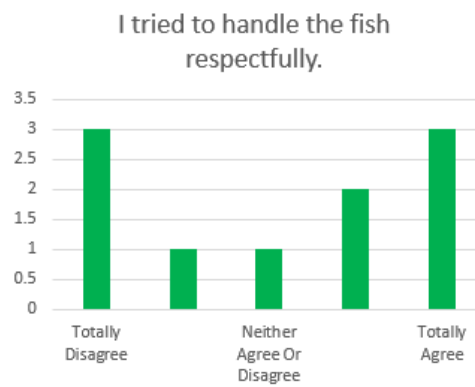
**Figure 6.20:** The university students’ responses to questions in the self-efficacy domain.



**Figure 6.21:** The university students’ responses to questions in the realism domain.



**Figure 6.22:** The university students' responses to questions in the Organization value domain.



**Figure 6.23:** The university students' responses to questions in the affective domain.

## 6.2.2 Qualitative data analysis

As previously mentioned in section 4.5.3, four fish farmers participated in an interview after having tested the application. This, along with the qualitative data gathered from text responses in the questionnaire, was thematically analyzed. Through this analysis, four main themes were found, which are **fish handling**, **model quality**, **application usability and improvements**, and **learning potential**. The following four sections will describe the details of the information found in the different themes. section 6.2.2 will also present the most reoccurring observations.

### Fish Handling

With fish handling being a subject all users in the final testing were asked about, fish handling became a natural theme. The users were not uniform in their opinion on how it was to handle the fish, though. But some topics and opinions reoccurred. Some opinions were also more prevalent in one user group than in another.

Many users found that handling the fish was difficult because it would at times wriggle uncontrollably when held. A few users had no problem with this, though, and found holding the fish to be easy and realistic. These users were only among the aquaculture and university students. Of the users that had difficulty with the shaking, some found it better to put the fish down on the table. The fish farmers had, however, an issue with how the fish would behave on the table. The fish is prone to turning its belly up when it is not in water on being held. All the fish farmers were adamant that that is not how a fish would behave.

Another issue that was almost universal for the fish farmers and aquaculture students was related to counting lice. The difficulties stemmed from the fact that users had to point at the lice with their right hand and mark them. Most of the users in the two aforementioned user groups had difficulties actually hitting the lice with the laser pointer and getting confirmation that they had marked the fish. The fish farmers also took issue with the fish marking solution, because it hindered the user from holding the fish with both hands, which is what one would usually do. The reason no user from the university student group had this issue is because the way lice marking was done was changed before they tested the application.

### Model Quality

With so much of the tasks in the application revolving around studying the fish, a lot of feedback were given on the quality of the fish models, and so model quality became another big theme. Some of what will be presented in this section does affect the handling of the fish, in the sense that how a user looks at the fish is related to how it handles it, and how they look at the fish is also related to the

quality of the models. Since so much of the qualitative data was about the quality of the models, it became natural to make it a separate theme.

The opinions on the quality of the models varied, but it seemed to be a higher level of similar opinions within the different user groups. Within the university student group, many users were impressed by the models and thought they looked good. The aquaculture students were less positive. Many of them felt the model was a bit unclear, which made it difficult to distinguish between lice and injuries. Some also felt the quality of the texture was too bad, which made it very difficult to rate them properly. Much of the aquaculture student's sentiment on the quality of the gills were also found among the fish farmers. The fish farmers' opinions on the quality of the rest of the fish model, though also negative, were a bit different. They did not seem to have that many issues with distinguishing between lice and injuries, but were more concerned with the fact that the different type of lice were not represented. There were, for example, impossible to see the difference between male, female and sexually mature lice. There is also no way in the application to register the different types of lice.

### **Application Usability and Improvements**

A lot has already been said about usability in the two previous sections, but there were some additional data on the subject that fit better under its own theme. There were also some users, primarily from the university student and fish farmer groups, that came with specific suggestions for improvements.

Many of the university students reported difficulties with rating sickness on the gills of the fish. Unlike the aquaculture students, they did not site poor model quality as the issue, but rather that they did not have enough preliminary knowledge to make an informed decision. Among those that mentioned this, many speculated that this likely was due to them not being in the target group, as they did not study anything related to aquaculture. Some of them did, nevertheless, suggest adding additional instructions on what to look for, either in the form of pictures or models.

A suggestion for improvement given by the fish farmers that is of particular interest, because the suggestion made it into the latest version of the application. This suggestion was to change how lice counting was done, from manually marking each louse on the fish with a laser pointer, to mentally counting the number of fish found and submitting the final count afterward. This, they felt, would make the task closer to how it is actually performed by them on the fish farm. It would also make it easier to hold the fish with both hands, which they also meant was more realistic. This suggestion was implemented into the application before the university students tested the application.

There were also two other suggestions made that have not been implemented. The first was to allow the gill covers to be grabbed and moved, to make access to the

gills simpler. This suggestion was made by aquaculture and university students. The other suggestion was made by the fish farmers, which was to make the table taller. This would make it so that the user would not have to bend so much over when inspecting the fish on the table.

### **Learning Potential**

The final theme that was identified is learning potential. This theme is about in what situations the application can be used for learning, and who may learn from it. Out of the four themes identified, this is the one with the smallest foundation of qualitative data, as it is based primarily on the interview with the four fish farmers.

The fish farmers did not have confidence in the application, in its current state, to be used as a tool for training fish farmers. The application does not represent their job accurately enough, and besides, they have easy access to actually doing the tasks that the application tries to simulate. They were more positive to the idea of using the application to teach high school or university students, though they felt the quality of the fish models probably still should improve before they are used in education. They also thought the application would be most helpful for aquaculture students that did not have as easy access to a fish farm as the high school students at Guri Kunna high school. Also, as was discussed in the previous section, the university students had difficulties with part of the application, because they lacked preliminary knowledge. The fish farmers thought the application could be used to introduce users to their workplace before they visit it in real life, so they can be a bit prepared for what tasks they need to do. Similarly, they thought the application would work great as a tool for introducing young jobseekers to their workplace. They also thought similar applications covering different aspects of their workplace could be useful both for training students and other people before they start working there.

### **Observations**

Throughout all the tests performed during the final testing, observations were made. The most recurring observations can be seen in table 6.4.

ID	Observation
O1	Aquaculture students and fish farmers have difficulties marking the fish.
O2	The fish would sometimes wriggle uncontrollably when held by the user.
O3	Sometimes fish would end up outside the start tank and float in the air.
O4	Most users seem to enjoy using the application.
O5	Many users from all groups are having difficulties rating the gills.
O6	The university students have more difficulties performing the tasks, apparently due to lack of experience or knowledge.
O7	The fish farmers lacking in video game experience take to the application surprisingly quickly.
O8	All the user seem to understand where they need to go.
O9	The fish farmers and aquaculture students seem to, in a higher degree than the university students, treat the fish with more respect. Some only after they notice the fish taking damage, when the application tells them, or they realize they are being scored on it.
O10	Some university student try to treat the fish respectfully after they notice the fish taking damage, when the application tells them, or they realize they are being scored on it. Others do not try at all.
O11	Some users seem confused about when the fish is calm. Some picked the fish up right after pouring the anesthesia into the water. Others waited, but seemed to expect some more immediate feedback than seeing the fish slowly calm down.
O12	Some users in the aquaculture and university student group do not seem to see the tool-tip that shows up after grabbing a fish, despite seemingly being a bit unsure of how to proceed.
O13	The aquaculture students are having difficulties distinguishing between lice and injuries.

**Table 6.4:** Observations made during final testing.



# Chapter 7

## Discussion

### 7.1 Design Choices

This section will discuss some design choices that were made during development.

#### 7.1.1 Leaving Some Unrealistic Objects

As described in section 5.7, the fish tanks and scoreboard were not changed to look more realistic, in an effort to utilize the gestalt principle of similarity (MacNamara, 2017) for a better user experience. The hope was that the users' eyes would be drawn to the objects in the application that stood out from the other realistic objects, i.e. the objects important for the different subtasks. It is difficult to determine how helpful this design choice was from the collected data. In retrospect, an A/B test could have been useful to determine this, but it would have taken valuable development time to implement the more realistic alternatives to the current models. As seen in table 6.4, the users did not seem to have difficulties knowing where to go, which this design choice may have contributed to, though that is only speculation. On the other hand, as described in section 2.1.6, a realistic environment increases the immersion of the application, which in turn increases presence that has a positive effect on learning outcomes (Makransky and Petersen, 2021). This means that the decision also could have had a negative impact on the application.

#### 7.1.2 The Inspection System

As mentioned in section 6.2, it was one alteration done between the testing on the 15th of May, with fish farmers and aquaculture students, and the later tests with university students. As described in section 5.4, this was that the system for counting the lice was changed from the user marking each louse individually with a laser pointer from their hand, similar to how they would press buttons, to the

user simply entering the number on a slider after counting the lice. This was done because almost all the users tested on the 15th of May had difficulties with the original system, as mentioned in section 6.2.2. It was deemed that the difficulties the user were having greatly impeded on their agency in the application, which could have a negative impact on the user's learning outcome (Makransky and Petersen, 2021). The replacement system was suggested by the fish farmers, as described in section 6.2.2. The change seems to have been a success, as none of the university students reported any issues with counting lice. The fish farmers also noted that making this change would make the application more accurate to real life. This could help increase the immersion of the application (Grajewski *et al.*, 2015).

### 7.1.3 Removing Tablet and Skills

It was mentioned in section 5.7 that the tablet, and subsequently VR4VET skills, were not implemented into the application. As described in sections 6.1.1 and 6.1.2, the tablet was in the initial versions of the application. However, users had difficulties with it getting in the way, when trying to pick up items from the floor. Some users also had issues with the design of the tablet itself. Given that the tablet is a VR4VET asset, it is not being developed in this project and fixing the issues found with it would be impossible. This is why it was decided to remove it from the application. After this decision was made, no more users had difficulties with picking up items from the floor, which suggests that the decision increased the usability of the application.

## 7.2 The Application

This section compares the features of the IVR application created during this master's project with the applications discussed in the related work in chapter 3. Table 7.1 shows the comparison of all the features. Cells with "✓" means that the corresponding application has that feature, and "÷" means it has it, but to a limited extent. Most of the applications discussed in chapter 3 did not have a name, so names that describe what they do are used in table 7.1. To avoid any confusion, table 7.2 shows what application belongs to what section in chapter 3.

As can be seen from table 7.1, animal welfare training and realistic animal interaction are the two unique features of the application. The dog anatomy application tests the users' knowledge of dog anatomy. The users of the application are veterinarians, which means the knowledge the applications test will be used to ensure welfare of dogs. So the application is indirectly supporting animal welfare. The virtual internship application has a task that is about feeding the fish, which is important for the welfare of the fish, but it is not the focus of the task. The virtual internship also allows the user to interact with fish, but the fish models are stiff and are undetailed. The improved fisheryVR application also has stiff undetailed

fish that can be interacted with.

What the application created for this project brings to the table, that none of the applications in table 7.1 does, is an immersive virtual workplace simulation for fish welfare training and awareness spreading.

Features	Related work				This Application
	Windmill VR	Dog Anatomy	Virtual internship	Improved FisheryVR	
IVR	✓	✓	✓	✓	✓
Real-world simulation	✓		✓	✓	✓
Workplace training		✓	✓	✓	✓
Blue sector			✓	✓	✓
Animal welfare training		÷	÷		✓
Realistic animal interaction			÷	÷	✓

**Table 7.1:** Feature comparison between the application created for this project and the applications from related work.

Application	Section
Windmill VR	Section 3.1
Dog Anatomy	Section 3.2
Virtual Internship	Section 3.3
Improved FisheryVR	Section 3.4

**Table 7.2:** This table shows what application belongs to what section in the related work chapter.

### 7.3 Research Questions

This section will address all the research questions posed by this thesis. The secondary research questions will be discussed first, as they will help answer the primary research question.

### **7.3.1 SRQ1: What needs are there for digital tools for visualizing or learning about fish welfare, and what of those needs can be addressed with the affordances of IVR?**

This research question was partially answered in the research project preceding this master's project. In that project it was found that there was a lack of practical training both in aquaculture studies and in training courses that are required for all fish farmers to take. It was also found that IVR as a digital tool was of particular interest, since it could simulate the practical lessons already in place. (Baugerud, 2022)

As described in section 6.2.2, the fish farmers did not believe they had the need for the application. This was both because they felt the application was not an accurate enough representation of their workplace, and because they have such easy access to doing the tasks, simulated in the application, in real life. They did believe, however, that aquaculture students without easy access to a fish farm could benefit from it, as well as young jobseekers that would want to be introduced to the workplace. This is in line with what have been found in previous research. The realism of the workplace simulated is important for the immersion of the application (Grajewski *et al.*, 2015), so inaccurate representation of the workplace will negatively impact the immersion of the user, especially the fish farmers, since they are the ones most familiar with the workplace. This is not a weakness of IVR as a medium, though, but of the application. The availability of training in the workplace for the fish farmers also mitigates one of the advantages of IVR, which is to simulate training where it otherwise would be impossible or dangerous (Renganayagalu *et al.*, 2021). Since it is more difficult for students and young jobseekers to access a fish farm, and because it can be more harmful to the fish to be handled by unprofessional people, the application seems to fit best for students and other untrained people.

Based on what has been found in this project and in the research project, then, it seems that the biggest need for digital tools for visualizing or learning about fish welfare is in practical training in education of aquaculture students, as a supplement to actual practical training. This makes IVR the ideal medium to cover this need. As presented in section 2.1.5, presence and agency are the main affordances of IVR, and they facilitate procedural knowledge very well. Transfer of learning can also be enhanced with the use of IVR (Makransky, Borre-Gude, *et al.*, 2019).

### **7.3.2 SRQ2: How should an IVR application, used for fish welfare training, be designed to meet the needs of such digital tools?**

The application produced through the course of this project is designed to teach users about fish welfare on a fish farm. By studying the development of this application, as well as the results from its user tests, one can learn something about how an IVR application used for visualizing or learning about fish welfare should

be designed to meet the needs of the aquaculture industry.

Firstly, to take advantage of the affordances of IVR, it is important that the tasks in the application cater to the type of knowledge that is best learned with IVR, which, as previously mentioned, is procedural knowledge. The main task of the application is to perform a fish welfare inspection. Using the cognitive domain from Bloom's taxonomy, the task "Perform a fish welfare inspection" can be broken into the verb "perform", which would belong in the apply category, and, importantly, the noun "fish welfare inspection" which can be categorized as procedural knowledge (Krathwohl, 2002). The VR4VET methodology was also used to design the task, which provides a guide on how to select a workplace task and break it into smaller parts, and providing adequate procedural and supportive information (VR4VET 2023). Using this methodology will make sure that the task is about procedural knowledge, which is useful when designing an IVR application for fish welfare training.

An important component of the application is the fish that the user must inspect. Both the aquaculture students and the fish farmers had issues with the quality of the models. As discussed in section 6.2.2, they had at times issues with seeing the texture clearly, and found it difficult to distinguish between injuries and lice. The fish farmers also felt it should be possible to distinguish between the different types of lice. As stated in section 6.2.2 it was also found that users in the same group had issues with handling the fish, because it did not behave realistically at times. It can also be seen in figure 6.11 that the aquaculture students had mixed, but largely negative, feelings on the realism of the fish. According to CAMIL, the fish not looking realistically negatively impacts the representational fidelity of the application, which again decreases presence, which will have a negative impact on the learning outcomes (Makransky and Petersen, 2021). The user not being able to see the fish clearly or handle it the way they want will have a negative impact on the control factors of the application. Similar to lack of representational fidelity, lack of control factors will decrease agency, which also has a negative impact on learning outcomes (Makransky and Petersen, 2021). The university student also had some struggles with handling the fish, but were more positive to the quality of the models, as can be seen in figure 6.21. For this user group, then, the quality of the models will have the opposite effect on representational fidelity and control factors. From SRQ1, in section 7.3.1, it was found that fish farmers may not be a good target group for the application, which means the models and behavior of the fish would not need to improve for their sake, but since aquaculture students were found to be a suitable target group, the quality of the fish model would need to be increased and its behavior improved.

The users seemed to be more in agreement on the realism of the environment in the application, compared to the fish models. As can be seen in figures 6.11 and 6.21, both the aquaculture students and the university students were more in agreement that the environment looked realistic. There were, however, still a significant amount of aquaculture students that neither agreed nor disagreed

with the environment being realistic. This could indicate that even though the realism of the environment is in a better state than that of the fish, there is still room for improvement. AS is presented in section 2.1.6, higher realism in the simulation of the workplace increases the immersion (Grajewski *et al.*, 2015). And the immersion of the application directly impacts the presence of the user. Same as with the realism of the fish, then, the realism of the environment will affect the learning outcomes of the application.

As mentioned in section 7.1.2, changing how the lice counting system worked lead to fewer users having difficulties with the counting system. This, in turn, probably increased the agency of the user in the application, which can increase situational interest (Schraw *et al.*, 2001). This, in turn, has a positive effect on learning (Harackiewicz *et al.*, 2016). This solution, as stated in section 6.2.2, was suggested by the fish farmers, because they felt it would make it easier, but crucially, also make the task more accurate to how it performed in real life. This highlights a potential flaw in the VR4VET methodology used to gather information on the tasks that will be simulated. As described in section 4.3, information on the task was gathered through interviewing the fish farmers, which adheres to the VR4VET methodology described in section 4.2. Details can easily be missed when interviewing someone about a task one does not personally have familiarity with. The fish farmers suggested that the developers of applications simulating their workplace should join the fish farmers in performing the task to get the best understanding. This method may be a better solution, and should be considered for future IVR applications being designed for teaching about fish welfare.

In section 6.2.2 it is described how the university students had difficulties with inspecting the gills of the fish for sickness, because they did not have any preliminary knowledge of what to look for and what constituted a rating. Many also felt they were not given enough instructions, and some suggested adding more, especially with example pictures. Further, some thought that it was because they were not in the target group of the application, which is not correct. Though the purpose of the application is not to train the university students, but rather to make them more aware of fish welfare in the aquaculture industry, the users not feeling that the application is made for them is not desirable. A user believing that an application is not made for them because they do not feel they have the knowledge could have a negative impact on their self-efficacy. They do not, however, give significantly less positive answers than the aquaculture students when asked "I am certain I can understand the concepts presented in the app.", as can be seen in figures 6.10 and 6.20. The average score for university students was 3.90, while the aquaculture students had 3.89, which is a negligible difference. When asked, "I am certain I could perform the tasks I learned in the app.", however, the aquaculture students were a little more positive, which can be seen in the same figures. The aquaculture students had an average score of 4.00, while the university students had 3.50. It must be reiterated that due to the low number of data points it is difficult to draw any real conclusions from this data alone, but

combined with the findings in the qualitative data it may seem that the university students' self-efficacy is negatively impacted by the lack of good instructions for them. As is described in section 2.1.5, self-efficacy is one of the affective and cognitive factors in CAMIL's model for learning in IVR (Makransky and Petersen, 2021). Lower self-efficacy will negatively impact the learning outcome of a user (Eccles and Wigfield, 2002), but focusing on giving good instructions for users without preliminary knowledge may help increase it.

There were not a lot of data collected on what the users thought about the layout of the application, or how they felt about navigating it. It was, however, observed that most users knew where to go in the application, which can be seen in table 6.4. This is an improvement from the application that was tested in the research projects, described in section 2.2. The principle of similarity was used in the design of the application, to try to make the application more user-friendly, which could have contributed to this, as discussed in section 7.1.1. The principle of proximity (MacNamara, 2017) can also have aided the user-friendliness of the application. The bottle used for sedation is placed close to the tank where fish should be sedated, the GUI for inspecting the fish is placed over the table where the fish can be put down when inspecting, and the scoreboard is close to the reawakening tank, which is the final destination for the fish. Placing all these objects, related to each other, close to each other could have made it easier to navigate the application. The user-friendliness could also partly be attributed to the principle of closure (MacNamara, 2017). Since all the objects for each subtask are placed close to each other and the subtasks are placed next to each other, this could be recognized as a linear pattern by the user. By continuing to move in the same direction, the user will move to the next subtask of the task. However, to what the degree the gestalt principles affect the user-friendliness of the application is impossible to tell from the data, unfortunately. Further research would need to be done on the application.

Figure 6.9 shows the aquaculture students' responses to questions regarding perceived learning. As was described in section 6.2.1, the responses to those questions are quite mixed, which can suggest that the aquaculture students did not experience any significant amount of perceived learning. The university students, on the other hand, seemed to have experienced more learning, as can be seen in figure 6.19. It can also be seen in each user groups' respective mean SUS score that the aquaculture students found the application less usable than the university students, with the former having a mean SUS score of 68.9 and the latter having 73.75. These scores are both considered as good, though, which suggests both groups found the application usable, to some extent. But the fact that the aquaculture students did not have any significant amount of perceived learning suggests that the IVR application developed in this project does not meet the needs for digital tools for visualizing or learning about fish welfare. As discussed in section 7.3.1, those needs are tools for practical training of aquaculture students. However, combining the suggestions for improvements with the aspects that worked

well with the application that have been discussed in this section may yield a better result.

### **7.3.3 SRQ3: How can the use of such an IVR application enhance training for people inside the aquaculture industry and raise awareness for people outside it?**

As is presented in section 2.1.6, multiple studies have found workplace training in IVR to yield better results than more traditional methods (Abidi *et al.*, 2019) (Makransky, Borre-Gude, *et al.*, 2019). An IVR application for learning about fish welfare could therefore yield better learning results than more traditional learning methods. The application created specifically for this project could help train aquaculture students in fish welfare. However, as discussed in the previous section, the application did not seem to be suited for training aquaculture students, which could be due to a number of faults that are discussed. The aquaculture students did give positive responses on two out of three questions regarding self-efficacy, which could indicate that the application gives the users a good sense of self-efficacy, which can have a positive effect on learning outcomes (Eccles and Wigfield, 2002) (Pajares, 1996). Figure 6.7 shows that the aquaculture students enjoyed using the application, as well. From the data collected in this project, though, it is not possible to discern if the level of enjoyment and self-efficacy experienced by the aquaculture students is greater than that they would feel using more traditional learning methods. That would require further research.

As for awareness for people outside the aquaculture industry, the results from the university students are more positive. Figure 6.19 indicates that the university student experienced a significant amount of perceived learning, and figure 6.17 shows that they also enjoyed the application. If a user after having tried the application feel they have learned something about fish welfare and fish farming and enjoyed the experience, they can be said to be more aware of the aquaculture industry. The university students did not give particularly positive responses to questions about the value the application had to them, which can be seen in figure 6.18. If the user does not perceive what they learn as valuable, they may be more prone to forget it, which would be negative for awareness. It is worth mentioning, however, that all the university students tested studied subjects unrelated to aquaculture, which could explain why they did not find the application valuable. Young jobseekers may find more value in the application, as (Prasolova-Førland *et al.*, 2019) already have found them to be positive towards IVR application for workplace training within the blue sector. More research is required to confirm this, though.

It can also be seen in figure 6.13 and from observation 9 in table 6.4 that the majority of the aquaculture students tried to treat the fish with respect. It was more mixed for the university students, however, as can be seen in figure 6.23 and from observation 10 in table 6.4. This may be because many of the aquaculture stu-



dents already learned the importance of treating the fish respectfully, or, in other words, have reached the *characterization* level of affective learning, from Bloom's taxonomy (Hoque, 2016). Though the university students' responses were mixed, more responded that they did try to treat the fish with respect than not. This can indicate that some of the university students experienced a level of affective learning, though likely only at the *responding* level (Hoque, 2016). If they did have an emotional response that they acted on when using the application, it could also help raise their awareness of fish welfare in the aquaculture industry. As described in section 7.3.1, young jobseekers were identified as a possible user group that the application could be well suited for. However, the application was never tested on young jobseekers, so this can not be confirmed. But if the application is well suited to raising awareness about fish welfare, this may support the idea that young jobseekers could be a suitable target group.

#### **7.3.4 PRQ: How can fish welfare training and awareness in the aquaculture industry be supported by Immersive Virtual Reality?**

This master's project produced an application that attempted to support fish welfare training and awareness in the aquaculture industry. This was done by simulating a task done in real life on a fish farm, which is to count lice and look for gill sickness on a fish. This is a practical task, which plays to the strengths of IVR, because that medium is well suited for procedural knowledge and transfer of learning (Radianti *et al.*, 2020) (Makransky, Borre-Gude, *et al.*, 2019). Simulating a realistic workplace has also been found to increase immersion (Grajewski *et al.*, 2015), which has a positive effect on learning outcomes (Makransky and Petersen, 2021). As discussed in section 7.3.1, there is a need for practical training of aquaculture students that could be supported by an IVR application such as the one created in this application. However, as discussed in section 7.3.2, the application does not seem to provide the training for aquaculture students that is intended. Multiple potential improvements are proposed in the same section that could make the application better support fish welfare training.

The application does seem to support awareness to a higher degree, though, as described in section 7.3.3. By using the application, university students were found to both learn something about fish farming, and they enjoyed the experience.

### **7.4 Unfulfilled Requirements**

The majority of the requirements for the applications, presented in section 4.4, were fulfilled in the final version of the application. However, as discussed in section 7.3.2, the application was found to have some limitations, and these limitations reveal that some of the requirements were not entirely reached. As some user had difficulties manipulating the fish the way they wanted, and the fish mov-

ing unrealistically at times, requirement 2, "The user should be able to hold and manipulate the fish in a realistic way.", is not entirely satisfied. It is not completely failed, though, as some users did find the handling realistic. Requirement 3, "The fish must have realistic, high quality textures to present all the necessary information.", is in a similar position to requirement 2. Also discussed in section 7.3.2, some users found the fish models to look realistic, while others, especially fish farmers and aquaculture students, had issues with the quality. Finally, As a direct result of Requirement 3 not being entirely fulfilled, Requirement 7, "The user must be able to count salmon lice on the fish and rate the fish's gill sickness, and get feedback on their performance.", is not entirely satisfied either, because if the user cannot get the required information from the fish model, they cannot properly count lice or assess gill sickness either.

## **7.5 Limitations**

Although the research done in this project was mostly conducted successfully, it has some limitations, one of which is the amount of participants. Due to the low number of people that participated in the user tests, the quantitative data analysis cannot be relied on too much. Though this issue is, to some extent, mitigated by the qualitative analysis, Some more definitive conclusions could maybe have been drawn with more quantitative data.

Another weakness is the lack of a control group during testing. If one group tested more traditional methods for fish welfare training and the other used the application, one could discern if there are any cognitive or affective domains that the application gives better learning outcomes for, compared to the traditional methods.

Finally, the testing only included a questionnaire after the users had tested the application. This means that there is no way to know if the user learned anything from the application. One can only measure whether the user felt they learned something or not. By including a test before and after the users try the applications, it would be possible to more accurately measure what the users have learned.

## Chapter 8

# Conclusion

This master's thesis has investigated the use of IVR for learning about and raising awareness of fish welfare in the aquaculture industry. It has been found that there is a need for digital tools for teaching aquaculture students about fish welfare. However, the application created for this project has issues that make its simulation of fish welfare inspection inaccurate to how it is done in real life, which limits its learning potential. However, the aquaculture students gave positive feedback in regard to value, enjoyment, and self-efficacy, which indicates that the application has potential. This potential may be realized through the future work described in section 8.2.

From the results, it seems that the application is better suited for raising awareness of fish welfare in the aquaculture industry among people outside it. The university students scored high on perceived learning and enjoyment, and may also have experienced some affective learning in the form of *receiving*. However, there is room for improvement here too, with the university students scoring low on self-efficacy.

### 8.1 Contributions

In addition to the results, this thesis has produced some artifacts that are of value in and of themselves. They can be used in future projects and research about IVR training for fish welfare and workplaces, in general. The artifacts are:

- The fish welfare IVR application
- The fish 3D models
- A tutorial task that can be used by other VR4VET applications to teach users the controls

## **8.2 Future Work**

This section will present different aspects of this thesis that could yield better results if worked on further.

### **8.2.1 The fish models**

Although the university students found the fish models realistic, some of the aquaculture students and all the fish farmers had issues with its quality. Working on making the fish models of even higher quality could help increase both the immersion and learning outcome for the application. At the same time, it could be interesting to look for ways to optimize the models so that they are better suited for the Quest 2 HMD.

### **8.2.2 The fish behavior**

The fish behavior was also found to be strange and unrealistic at times, and some user found the fish difficult to handle. Making the fish handling and behavior better would improve the application. It could potentially improve both presence and agency in the application.

### **8.2.3 Instructions**

The university students in particular had difficulties with knowing how to complete the tasks, because they had no experience with fish farming. Adding better instructions to the application, possibly with example pictures or models, could fix this.

### **8.2.4 Improved research method**

This master's thesis has tested the viability of the IVR application created as a tool for learning about fish welfare in the aquaculture industry. However, as mentioned in section 7.5, it's difficult to know how well the application works as a learning tool compared to traditional learning methods. In the future, it would be interesting to perform such a comparison. The same goes for having a test before and after a user tries the application. This would help contextualize how effective of a learning tool the application really is. Also mentioned in section 7.5, more participants should partake in any future research, to make the quantitative data analysis more robust. Moreover, it would be interesting to include young jobseekers in future research to test if they actually are a suitable target group for the application.

Finally, improving the method used by VR4VET to gather information from interviewing employers to actually performing the tasks that is being simulated could be interesting, and might improve the accuracy of the application's representation of the task.

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## **Appendix A**

# **Consent Form**

# **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** 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, virtual field trips, remote learning, visualization of climate change, immersive visualization of lab experiments, workplace training, visualization of medical procedures and anatomy and other projects. In this form 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, virtual field trips, remote learning in COVID-19 context, visualization of climate change, immersive visualization of lab experiments, workplace training, visualization of medical procedures and anatomy and other projects. 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. We might take some anonymized photos/videos (with faces partly hidden behind the VR/AR headsets) during the testing sessions.

### **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/bachelor 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 31.12.2023. 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](mailto:ekaterip@ntnu.no)
- NSD – The Norwegian Centre for Research Data AS, by email: ([personverntjenester@nsd.no](mailto:personverntjenester@nsd.no)) or by telephone: +47 55 58 21 17.

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## **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. 31.12.2023

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(Signed by participant, date)





## **Appendix B**

# **Interview Guide for Fish Farmers**

Hva synes du om applikasjonen?

Var applikasjonen enkel å bruke?

Var det noe i applikasjonen som virket ulogisk eller ikke fungerte som du forventet?

Syns du applikasjonen var en god representasjon av den virkelige jobben dere gjør?

Er det deler av applikasjonen som burde endres eller forbedres?

Tror du en slik applikasjonen kan brukes til opplæring av ansatte på fiskeoppdrett?

Tror du applikasjonen kan brukes til undervisning for elever på VGS eller studenter ved universitet?

Tror du denne applikasjonen kan brukes i en karriereveiledningssammenheng, for å gi innblikk i yrket?

## **Appendix C**

# **Transcribed interview with Fish Farmers**

Intervjuer: Jeg vil bare starte litt generelt. Hva syns dere om appen?

Person 1: Artig påfunn. helt greit

Person 2: syns det var greit jeg. Var litt uklare bilder, men det var nå så.

Person 3: forbedringspotensiale

Person 4: Nye bilder til fiskene for eksempel. Og nye friske fisker hadde gjort mye. Ellers var det gøy egentlig.

Intervjuer: syns dere applikasjonen var enkel å bruke?

Person 2: jeg, for min del, har aldri vært borti et TV-spill i hele mitt liv, men det gikk

Person 4: jeg syns det gikk greit

Intervjuer: var det noe dere syns var vanskelig, eller var det helt greit?

Person 3: det gikk veldig greit.

Person 4: grei instruksjon.

Intervjuer: var det noe applikasjonen som virket ulogisk, eller ikke fungerte som forventet?

Person 1: fisken forsvant.

Person 3: fisken svømte under bordet

Person 1: ellers var det greit tror jeg.

Intervjuer: syns dere appen var en god representasjon av den virkelige jobben dere gjør her? Når dere teller lus?

Flere personer: jo, ja

Person 4: det er jo sånn det foregår.

Intervjuer: Dere har jo nevnt litt på det allerede, men er det deler av applikasjonen dere syns bør endres eller forbedres?

Person 4: Behandlinga av fisken. Håndteringen av fisken.

Person 1: Håndteringen av fisken, ja.

Person 4: håndteringen av fisken. Der er det en vei å gå altså. Bildene bør også være bedre. Om man skal vise fiskene til elever og prøve lære de, så må bildene være bedre.

Person 3: måten du håndterer den på.

Person 2: Det er jo to-hånds-grep i virkeligheten. Ikke en hånd.

Person 4: Ja, ble jo nødt å holde med en hånd når man skulle peke med den andre. Men man har jo mulighet til å legge den på bordet, selvsagt, og snu på den. Men på bordet snudde den med buken opp med en gang. Det er ikke riktig.

Person 2: Ja, det må være litt mer presist.

Person 4: mer presist, ja. Og litt zoom kanskje, på hvor nærme man kan se.

Person 3: ikke ha bordet så lavt kanskje.

Person 4: ja, det er kanskje en løsning.

Person 3: Man blir sittende å se rett ned når man holder på med fisken på bordet. Så kanskje ha bordet ikke nødvendigvis i hodehøyde, men litt høyere opp.

Person 2: når vi står å teller lus på ekte så står vi med fisken hendene, og holder den helt oppe i ansiktet, og kan snu og se på den.

Person 4: om dere vil kan dere være med ut å telle en gang og se hvordan det gjøres.

Intervjuer. Ja om vi skal ta det videre, så er jo det veldig nyttig.

Person 1: Hadde ikke vært nødvendig å trykke på lusen. Kunne bare holdt den og telt lus i hodet. Og så i etterkant oppgi hvor mange det var.

Person 2: ja, enig med deg

Person 1: ja kan ha det i hodet og legge det inn etterpå.

Person 4: også må man få lagt inn kjønnsmodne og bevegelige lus i appen. Det er jo det vi virkelig teller. Egentlig burde dere som lager appen ha grunnkunnskapen og være med på sjøen for å se hvordan det gjøres.

Intervjuer: vi var på besøk i februar, men da jeg jeg det bare forklart.

Person 4: åja, men det blir for dårlig.

Intervjuer: Tror dere en slik applikasjon kunne blitt brukt for trening av ansatte som dere, her på oppdrettet?

Person 4: Da må det nok bli litt mer nøye, tenker jeg.

Person 2: ja

Person 1: Ja det er litt arbeid med det, men det er ikke umulig.

Person 4: Nei, det er ikke umulig. Det tenker jeg og. Men det vi spesialisere oss på med, hva slags type lus, kjønnsmodne han- og hu-lus og sånt. Det tror jeg er vanskelig å få bilder med god kvalitet av. Ellers har vi god håndtering på blanding av bedøvelse og håndtering av fisk. Det er det vel vi som kan lære dere.

Person 1: Det er vel helst for folk som aldri har vært borti det her.

Person 4: sånn som det er nå, i hvert fall.

Intervjuer: tror dere appen kunne blitt brukt for elever ved videregående skole, eller for studenter ved universitet?

Person 2: Det tror jeg.

Intervjuer: er det mer passende?

Person 2: ja

Person 4: ja

Person 3: En slags opplæring før folk kommer hit.

Person 2: Det tror jeg hadde vært kjempebra.

Intervjuer: ja, for det er jo ingenting som slår praktisk arbeid.

Flere personer: Enig i det

Intervjuer: Men det er ikke alltid så lett å få til, så appen kunne kanskje vært et bedre alternativ enn å sitte og lese om det.

Person 2: ja

Person 3: Prøve å få til et lett tilgjengelig tilbud. Den videregående skolen som er her har jo god tilgjengelighet for å komme ut på oppdrettet. Men andre plasser er det kanskje ikke like lett å komme ut og faktisk få prøvd det.

Person 4: ja, enig

Person 3: Så før man tar seg 3 timers kjøreturen ut hit så kan man prøve appen og se hva det handler om.

Person 4: Det blir jo litt som en liten teoretisk time før de skal ut i felten første gang. Så det er greit å få inn litt teori først.

Person 2: Det er jo noen som kummer ut hit og er helt grønn på hva vi holder på med.

Person 1: Er det kun lusetelling dere holder på med i det prosjektet her?

Intervjuer: Det er det jeg holder på med. Men det er del av et større prosjekt. En annen gruppe har laget en om foring av laksen. Kan hende at det kommer flere apper senere og.

Intervjuer: siste spørsmål. Tror dere applikasjonen kunne blitt brukt i en karriereveiledningssammenheng? For å få et innblikk i hva det er dere driver med her. For eksempel, om unge jobbsøkere kan prøve en slik app jos NAV.

Person 1: ja

Person 2: Går sikkert det.

Person 4: Der er jo klart. Sammen mange andre forskjellige apper om fiskeoppdrett kanskje. Båtbruk og foring og sånt, sånn at de får et bilde av hele arbeidsplassen.

Intervjuer: Så du tror det er noe som kunne funka?

Person 4: ja, absolutt.

Intervjuer: er det noen kommentarer dere har lyst til å legge til helt til slutt?

Ingen kommentarer





## **Appendix D**

# **Questionnaire for Fish Farmers**

## Fiskevelferd - brukertest

### Bakgrunn

#### Hvor mye erfaring har du med dataspill?

- Ingen
- Lite
- Noe
- Mye
- Veldig mye

#### Hvor mye erfaring har du med VR?

VR står for "Virtual Reality" eller virtuell virkelighet.

- Ingen
- Lite
- Noe
- Mye
- Veldig mye

#### Hvor mye erfaring har du med fiskeoppdrett?

VR står for "Virtual Reality" eller virtuell virkelighet.

- Ingen
- Lite
- Noe
- Mye
- Veldig mye

### Kjønn

- Mann
- Kvinne
- Annet
- Ønsker ikke å oppgi

### Alder

#### Jeg likte å bruke applikasjonen.

- Svært enig
- Ganske enig
- Verken enig eller uenig
- Litt uenig
- Svært uenig

#### Det var lett å bruke applikasjonen.

- Svært enig
- Ganske enig

Verken enig eller uenig

Litt uenig

Svært uenig

### **Brukervennlighet**

**Jeg tenker at jeg vill bruke appen regelmessig.**

1

2

3

4

5

**Jeg synes appen er unødvendig komplekse.**

1

2

3

4

5

**Jeg synes appen var enkelt å bruke.**

1

2

3

4

5

**Jeg tror at jeg ville trenge støtte fra en veileder som forklarer hva jeg skal gjøre for å bruke appen på riktig måte.**

1

2

3

4

5

**Jeg synes appens funksjoner er godt integrert.**

1

2

3

4

5

**Jeg synes det var for lite logisk sammenheng i appen.**

1

2

3

4

5

**Jeg kan tenke meg at de fleste ville lære å bruke appen svært raskt.**

1

2

3

4

5

**Jeg synes appen er veldig tungvint å bruke.**

1

2

3

4

5

**Jeg følte meg veldig trygg på å bruke appen.**

1

2

3

4

5

**Jeg trengte å lære mye før jeg kunne komme i gang med denne appen.**

1

2

3

4

5

**Til slutt...**

**Har du noe mer du ønsker å si om applikasjonen?**

## **Appendix E**

# **Questionnaire Results for Fish Farmers**





## Fiskevelferd - brukertest

Oppdatert: 10. juni 2023 kl. 23:34

### Bakgrunn




#### Hvor mye erfaring har du med dataspill?

Antall svar: 5

Svar	Antall	% av svar	
Veldig mye	1	20%	 20%
Mye	1	20%	 20%
Noe	0	0%	0%
Lite	2	40%	 40%
Ingen	1	20%	 20%






#### Hvor mye erfaring har du med VR?

Antall svar: 5

Svar	Antall	% av svar	
Veldig mye	0	0%	0%
Mye	0	0%	0%
Noe	2	40%	 40%
Lite	1	20%	 20%
Ingen	2	40%	 40%





## Hvor mye erfaring har du med fiskeoppdrett?

Antall svar: 5

Svar	Antall	% av svar	
Veldig mye	3	60%	 60%
Mye	1	20%	 20%
Noe	1	20%	 20%
Lite	0	0%	 0%
Ingen	0	0%	 0%

## Kjønn

Antall svar: 5

Svar	Antall	% av svar	
Ønsker ikke å oppgi	0	0%	 0%
Annet	0	0%	 0%
Kvinne	0	0%	 0%
Mann	5	100%	 100%

## Alder

• 40

• 34

• 33

• 31

• 62

## Jeg likte å bruke applikasjonen.

Antall svar: 5

Svar	Antall	% av svar	
Svært uenig	0	0%	0%
Litt uenig	0	0%	0%
Verken enig eller uenig	1	20%	20%
Ganske enig	1	20%	20%
Svært enig	3	60%	60%

## Det var lett å bruke applikasjonen.

Antall svar: 5

Svar	Antall	% av svar	
Svært uenig	0	0%	0%
Litt uenig	0	0%	0%
Verken enig eller uenig	0	0%	0%
Ganske enig	5	100%	100%
Svært enig	0	0%	0%

## Brukervennlighet

### Jeg tenker at jeg vill bruke appen regelmessig.

Antall svar: 5

Svar	Antall	% av svar	
5	0	0%	0%
4	1	20%	20%
3	1	20%	20%
2	3	60%	60%
1	0	0%	0%



## Jeg synes appen er unødvendig kompleks.

Antall svar: 5

Svar	Antall	% av svar	
5	0	0%	0%
4	1	20%	20%
3	0	0%	0%
2	2	40%	40%
1	2	40%	40%

## Jeg synes appen var enkelt å bruke.

Antall svar: 5

Svar	Antall	% av svar	
5	2	40%	40%
4	2	40%	40%
3	0	0%	0%
2	1	20%	20%
1	0	0%	0%





## Jeg tror at jeg ville trenge støtte fra en veileder som forklarer hva jeg skal gjøre for å bruke appen på riktig måte.

Antall svar: 5

Svar	Antall	% av svar	
5	0	0%	0%
4	1	20%	20%
3	3	60%	60%
2	1	20%	20%
1	0	0%	0%





## Jeg synes appens funksjoner er godt integrert.

Antall svar: 5

Svar	Antall	% av svar	
5	1	20%	 20%
4	2	40%	 40%
3	1	20%	 20%
2	1	20%	 20%
1	0	0%	0%




## Jeg synes det var for lite logisk sammenheng i appen.

Antall svar: 5

Svar	Antall	% av svar	
5	0	0%	0%
4	1	20%	 20%
3	1	20%	 20%
2	2	40%	 40%
1	1	20%	 20%

## Jeg kan tenke meg at de fleste ville lære å bruke appen svært raskt.

Antall svar: 5

Svar	Antall	% av svar	
5	1	20%	 20%
4	2	40%	 40%
3	2	40%	 40%
2	0	0%	0%
1	0	0%	0%

## Jeg synes appen er veldig tungvint å bruke.

Antall svar: 5

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	4	80%	80%
1	1	20%	20%

## Jeg følte meg veldig trygg på å bruke appen.

Antall svar: 5

Svar	Antall	% av svar	
5	3	60%	60%
4	1	20%	20%
3	1	20%	20%
2	0	0%	0%
1	0	0%	0%

## Jeg trengte å lære mye før jeg kunne komme i gang med denne appen.

Antall svar: 5

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	2	40%	40%
2	2	40%	40%
1	1	20%	20%

Til slutt...

## Har du noe mer du ønsker å si om applikasjonen?

Dette spørsmålet har ingen svar



## **Appendix F**

# **Questionnaire for Aquaculture Students and University Students**

## **Fiskevelferd - brukertest - utvidet - studenter v2**

### **Bakgrunn**

**Skriv inn nummeret du ble tildelt.**

**Hvor mye erfaring har du med dataspill?**

- Ingen
- Lite
- Noe
- Mye
- Veldig mye

**Hvor mye erfaring har du med VR?**

VR står for "Virtual Reality" eller virtuell virkelighet.

- Ingen
- Lite
- Noe
- Mye
- Veldig mye

**Hvor mye erfaring har du med fiskeoppdrett?**

VR står for "Virtual Reality" eller virtuell virkelighet.

- Ingen
- Lite
- Noe
- Mye
- Veldig mye

### **Kjønn**

- Mann
- Kvinne
- Annet
- Ønsker ikke å oppgi

### **Alder**

**Jeg likte å bruke applikasjonen.**

- Svært enig
- Ganske enig
- Verken enig eller uenig
- Litt uenig
- Svært uenig

**Det var lett å bruke applikasjonen.**

- Svært enig

Ganske enig

Verken enig eller uenig

Litt uenig

Svært uenig

### **Brukervennlighet**

**Jeg tenker at jeg vil bruke appen regelmessig.**

1

2

3

4

5

**Jeg synes appen er unødvendig kompleks.**

1

2

3

4

5

**Jeg synes appen var enkel å bruke.**

1

2

3

4

5

**Jeg tror jeg vil trenge støtte fra en veileder som forklarer hva jeg skal gjøre for å bruke appen på riktig måte.**

1

2

3

4

5

**Jeg synes appens funksjoner er godt integrert.**

1

2

3

4

5

**Jeg synes det var for lite logisk sammenheng i appen.**

1

- 2
- 3
- 4
- 5

**Jeg kan tenke meg at de fleste lærer seg å bruke appen svært raskt.**

- 1
- 2
- 3
- 4
- 5

**Jeg synes appen er veldig tungvin å bruke.**

- 1
- 2
- 3
- 4
- 5

**Jeg følte meg veldig trygg på å bruke appen.**

- 1
- 2
- 3
- 4
- 5

**Jeg trengte å lære mye før jeg kunne komme i gang med denne appen.**

- 1
- 2
- 3
- 4
- 5

**Opplevelse**

**Jeg opplevde ubehag da jeg brukte appen.**

- 1
- 2
- 3
- 4
- 5

**Jeg ble kvalm da jeg brukte appen.**

- 1



- 2
- 3
- 4
- 5

**Jeg ble sliten i øynene av å bruke appen.**

- 1
- 2
- 3
- 4
- 5

**Jeg synes det var gøy å bruke appen.**

- 1
- 2
- 3
- 4
- 5

**Jeg synes en slik type app er veldig interessant.**

- 1
- 2
- 3
- 4
- 5

**Oppgavene i appen greide ikke å holde oppmerksomheten min.**

- 1
- 2
- 3
- 4
- 5

**Jeg tror det har verdi for meg å bruke en slik app.**

- 1
- 2
- 3
- 4
- 5

**Jeg kunne tenkt meg å brukt en slik app igjen fordi det ville hatt verdi for meg.**

- 1
- 2
- 3

4

5

**Jeg lærte mye om fiskevelferd når jeg brukte appen.**

1

2

3

4

5

**Jeg har fått en grunnleggende forståelse for hvordan lusetelling gjennomføres.**

1

2

3

4

5

**Jeg kan bruke det jeg lærte i appen i et virkelig scenario.**

1

2

3

4

5

**Jeg tror jeg kunne gitt en god forklaring av lusetellingsprosessen til en medstudent eller kollega**

1

2

3

4

5

**Jeg er sikker på at jeg kan forstå koseptene presentert i appen.**

1

2

3

4

5

**Jeg er sikker på at jeg kunne gjennomført oppgavene jeg lærte i appen.**

1

2

3

4

5

**Jeg føler jeg har lært noe om fiskeoppdrett etter å prøvd appen.**

1

2

3

4

5

**Jeg er mer interessert i fiskeoppdrett etter å ha prøvd appen.**

1

2

3

4

5

**Jeg syns omgivelsene var realistiske.**

1

2

3

4

5

**Jeg syns fisken så og oppførte seg realistisk.**

1

2

3

4

5

**Jeg prøvde å behandle fisken med respekt.**

1

2

3

4

5

**Til slutt...**

**Hvordan var det å håndtere fisken?**

**Hvordan var det å telle lus?**

**Hvordan var det å se etter sykdom på gjellene?**



## **Appendix G**

# **Questionnaire Results for Aquaculture Students**

## Fiskevelferd - brukertest - utvidet

Oppdatert: 10. juni 2023 kl. 23:34

### Bakgrunn

Skriv inn nummeret du ble tildelt.

• 6

• 8

• 7

• 6

• 5

• 3




• 4

• 2

• 1

### Hvor mye erfaring har du med dataspill?

Antall svar: 9

Svar	Antall	% av svar	
Veldig mye	0	0%	0%
Mye	3	33.3%	 33.3%
Noe	3	33.3%	 33.3%
Lite	4	44.4%	 44.4%
Ingen	0	0%	0%

## Hvor mye erfaring har du med VR?

Antall svar: 9

Svar	Antall	% av svar	
Veldig mye	0	0%	0%
Mye	1	11.1%	11.1%
Noe	2	22.2%	22.2%
Lite	3	33.3%	33.3%
Ingen	3	33.3%	33.3%

## Hvor mye erfaring har du med fiskeoppdrett?

Antall svar: 9

Svar	Antall	% av svar	
Veldig mye	0	0%	0%
Mye	5	55.6%	55.6%
Noe	4	44.4%	44.4%
Lite	0	0%	0%
Ingen	0	0%	0%

## Kjønn

Antall svar: 9




Svar	Antall	% av svar	
Ønsker ikke å oppgi	0	0%	0%
Annet	0	0%	0%
Kvinne	3	33.3%	33.3%
Mann	6	66.7%	66.7%

## Hvor gammel er du

- 17
- 16
- 17
- 17
- 16
- 17
- 16
- 16
- 16



## Jeg likte å bruke applikasjonen.

Antall svar: 9

Svar	Antall	% av svar	
Svært uenig	0	0%	0%
Litt uenig	0	0%	0%
Verken enig eller uenig	2	22.2%	 22.2%
Ganske enig	7	77.8%	 77.8%
Svært enig	1	11.1%	 11.1%

## Det var lett å bruke applikasjonen.

Antall svar: 9

Svar	Antall	% av svar	
Svært uenig	0	0%	0%
Litt uenig	0	0%	0%
Verken enig eller uenig	6	66.7%	 66.7%
Ganske enig	3	33.3%	 33.3%
Svært enig	0	0%	0%

## Brukervennlighet



## Jeg tenker at jeg vill bruke appen regelmessig.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	3	33.3%	33.3%
3	1	11.1%	11.1%
2	5	55.6%	55.6%
1	0	0%	0%

## Jeg synes appen er unødvendig kompleks.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	1	11.1%	11.1%
2	4	44.4%	44.4%
1	4	44.4%	44.4%





## Jeg synes appen var enkelt å bruke.

Antall svar: 9

Svar	Antall	% av svar	
5	1	11.1%	11.1%
4	5	55.6%	55.6%
3	3	33.3%	33.3%
2	0	0%	0%
1	0	0%	0%




## Jeg tror at jeg ville trenge støtte fra en veileder som forklarer hva jeg skal gjøre for å bruke appen på riktig måte.

Antall svar: 9

Svar	Antall	% av svar	
5	2	22.2%	 22.2%
4	0	0%	0%
3	2	22.2%	 22.2%
2	3	33.3%	 33.3%
1	2	22.2%	 22.2%





## Jeg synes appens funksjoner er godt integrert.

Antall svar: 9

Svar	Antall	% av svar	
5	1	11.1%	 11.1%
4	1	11.1%	 11.1%
3	7	77.8%	 77.8%
2	0	0%	0%
1	0	0%	0%




## Jeg synes det var for lite logisk sammenheng i appen.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	1	11.1%	 11.1%
3	2	22.2%	 22.2%
2	5	55.6%	 55.6%
1	1	11.1%	 11.1%




## Jeg kan tenke meg at de fleste ville lære å bruke appen svært raskt.

Antall svar: 9

Svar	Antall	% av svar	
5	3	33.3%	 33.3%
4	4	44.4%	 44.4%
3	2	22.2%	 22.2%
2	0	0%	0%
1	0	0%	0%




## Jeg synes appen er veldig tungvint å bruke.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	2	22.2%	 22.2%
2	3	33.3%	 33.3%
1	4	44.4%	 44.4%

## Jeg følte meg veldig trygg på å bruke appen.

Antall svar: 9

Svar	Antall	% av svar	
5	4	44.4%	 44.4%
4	2	22.2%	 22.2%
3	3	33.3%	 33.3%
2	0	0%	0%
1	0	0%	0%

## Jeg trengte å lære mye før jeg kunne komme i gang med denne appen.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	2	22.2%	22.2%
3	0	0%	0%
2	4	44.4%	44.4%
1	3	33.3%	33.3%

## Opplevelse

### Jeg opplevde ubehag da jeg brukte appen.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	0	0%	0%
1	9	100%	100%

### Jeg ble kvalm da jeg brukte appen.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	0	0%	0%
1	9	100%	100%

## Jeg ble sliten i øynene av å bruke appen.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	1	11.1%	11.1%
2	1	11.1%	11.1%
1	7	77.8%	77.8%

## Jeg synes det var gøy å bruke appen.

Antall svar: 9

Svar	Antall	% av svar	
5	6	66.7%	66.7%
4	3	33.3%	33.3%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Jeg synes en slik type app er veldig interessant.

Antall svar: 9

Svar	Antall	% av svar	
5	5	55.6%	55.6%
4	3	33.3%	33.3%
3	1	11.1%	11.1%
2	0	0%	0%
1	0	0%	0%

## Oppgavene i appen greide ikke å holde oppmerksomheten min.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	3	33.3%	33.3%
1	6	66.7%	66.7%

## Jeg tror det har verdi for meg å bruke en slik app.

Antall svar: 9

Svar	Antall	% av svar	
5	1	11.1%	11.1%
4	5	55.6%	55.6%
3	2	22.2%	22.2%
2	1	11.1%	11.1%
1	0	0%	0%

## Jeg kunne tenkt meg å brukt en slik app igjen fordi det ville hatt verdi for meg.

Antall svar: 9

Svar	Antall	% av svar	
5	1	11.1%	11.1%
4	2	22.2%	22.2%
3	5	55.6%	55.6%
2	1	11.1%	11.1%
1	0	0%	0%

## Jeg lærte mye om fiskevelferd når jeg brukte appen.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	1	11.1%	11.1%
2	6	66.7%	66.7%
1	2	22.2%	22.2%

## Jeg har fått en grunnleggende forståelse for hvordan lusetelling gjennomføres.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	4	44.4%	44.4%
3	0	0%	0%
2	4	44.4%	44.4%
1	1	11.1%	11.1%

## Jeg kan bruke det jeg lærte i appen i et virkelig scenario.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	3	33.3%	33.3%
3	4	44.4%	44.4%
2	2	22.2%	22.2%
1	0	0%	0%

## Jeg tror jeg kunne gitt en god forklaring av lusetellingsprosessen til en medstudent eller kollega

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	2	22.2%	22.2%
3	5	55.6%	55.6%
2	2	22.2%	22.2%
1	0	0%	0%

## Jeg er sikker på at jeg kan forstå koseptene presentert i appen.

Antall svar: 9

Svar	Antall	% av svar	
5	1	11.1%	11.1%
4	6	66.7%	66.7%
3	2	22.2%	22.2%
2	0	0%	0%
1	0	0%	0%

## Jeg er sikker på at jeg kunne gjennomført oppgavene jeg lærte i appen.

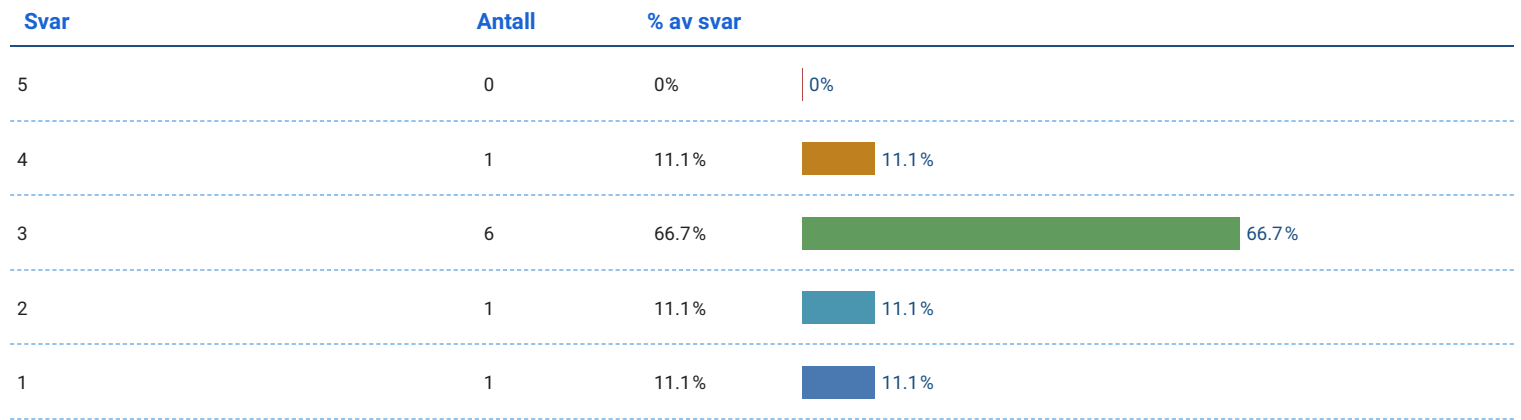
Antall svar: 9

Svar	Antall	% av svar	
5	5	55.6%	55.6%
4	1	11.1%	11.1%
3	2	22.2%	22.2%
2	1	11.1%	11.1%
1	0	0%	0%



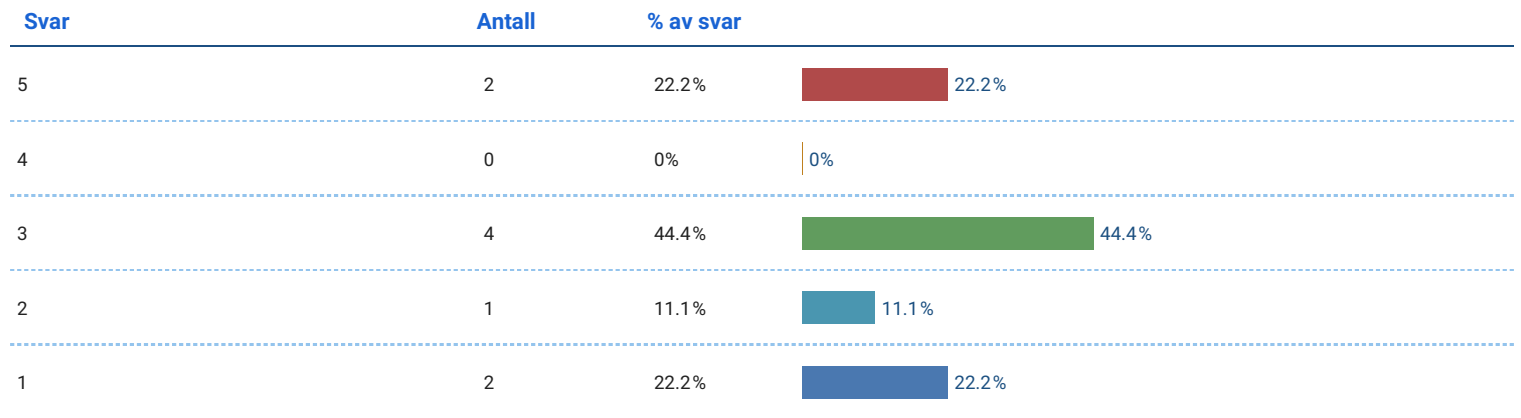
## Jeg føler jeg har lært noe om fiskeoppdrett etter å prøvd appen.

Antall svar: 9



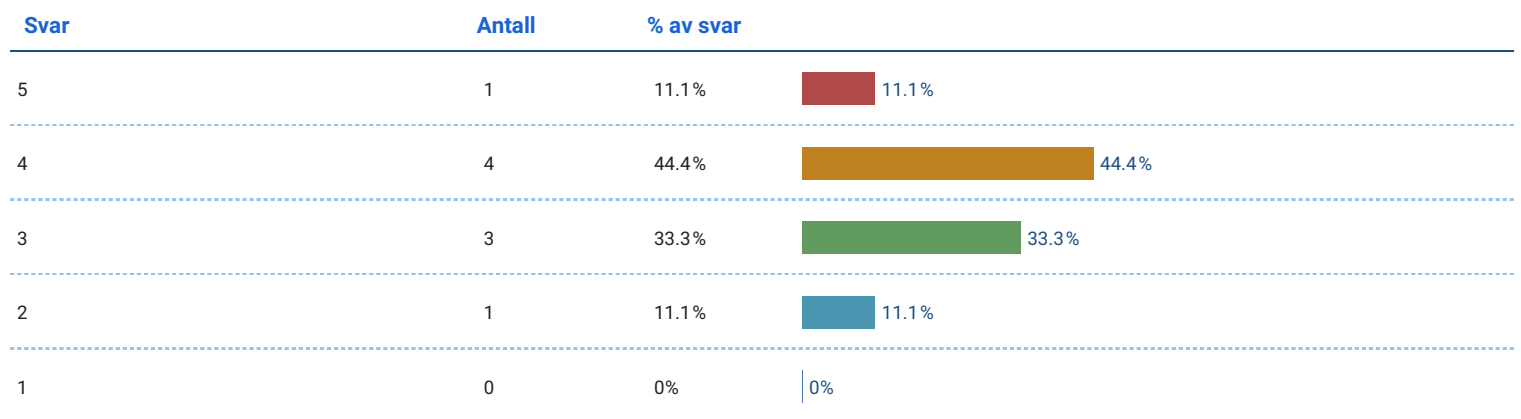
## Jeg er mer interessert i fiskeoppdrett etter å ha prøvd appen.

Antall svar: 9



## Jeg syns omgivelsene var realistiske.

Antall svar: 9



## Jeg syns fisken så og oppførte seg realistisk.

Antall svar: 9

Svar	Antall	% av svar	
5	0	0%	0%
4	2	22.2%	22.2%
3	2	22.2%	22.2%
2	3	33.3%	33.3%
1	2	22.2%	22.2%

## Jeg prøvde å behandle fisken med respekt.

Antall svar: 9

Svar	Antall	% av svar	
5	4	44.4%	44.4%
4	1	11.1%	11.1%
3	3	33.3%	33.3%
2	1	11.1%	11.1%
1	0	0%	0%

## Til slutt...

### Hvordan var det å håndtere fisken?

- Helt greit.
- Noe vanskelig å få holdt fisken i ro for så eks se på gjellene.
- Jeg synes at fisken bevegde seg mye når man holdt den i luften. Det var også litt ekkelt og holde den slik at du fikk rotere den på den måten du ville.
- Litt vanskelig
- Vanskelig å holde den
- Litt vanskelig, men gikk greit
- Det var ikke noe problem å håndtere fisken. Fisken lå realistisk på bordet.
- Den var som en ekte fisk som ristet i hendene dine. Men var ekkelt når man holdt til med begge hendene.
- Den ristet litt som gjorde det litt vanskelig å se på den

## Hvordan var det å telle lus?

---

- Vanskelig, greide ikke å skille lus fra sår
- Fisken var noe uklar og det var derfor vanskelig å skille mellom lus og sår. Litt vanskelig å markere lusa og.
- Det var enklest å telle lus men det var vanskelig å få bekreftelse på at du fant en lus. Lusen kunne også minne om sår så det var lett å blande.
- Vrient, fordi at jeg ikke fikk til laseren
- Jeg fikk det ikke til, vanskelig å se lusa
- Vanskelig å se om det var lus, samt at d var vanskelig å se om lusa du fant ble registrert.
- Det var vanskelig å se forskjellen på sår og lus.
- Var litt uklare bilder så vanskelig å se lusen, også var det vanskelig å se lungene.
- Jeg misforstod å telte ikke lus

## Hvordan var det å se etter sykdom på gjellene?

---

- Vanskelig, gjellene på fiskene så like ut
- Vanskelig, veldig uklart.
- Det var veldig vanskelig alle gjellene så like ut bortsett fra en som var helt svart. Jeg vil si at det egentlig er helt umulig å greie å bedømme graden på gjeldende
- Enkelt
- Helt ok
- Vanskelig å se, for uklart
- Det var litt vanskelig å skille gjellene til fiskene fra hverandre. De fleste så veldig like ut.
- Det var vanskelig med tanke på kvalitet men gjellene var greie å komme fram til.
- Greit. Litt vanskelig å se når det ikke går ant å flytte litt på gjellelokkene



## **Appendix H**

# **Questionnaire Results for University students**

# Fiskevelferd - brukertest - utvidet - studenter v2

Oppdatert: 10. juni 2023 kl. 23:34

## Bakgrunn

Skriv inn nummeret du ble tildelt.

• 10

.....

• 9

.....

• 9

.....

• 8

.....

• 6

.....

• 5

.....

• 4




.....

• 3

.....





## Hvor mye erfaring har du med dataspill?

Antall svar: 8

Svar	Antall	% av svar	
Veldig mye	3	37.5%	 37.5%
Mye	4	50%	 50%
Noe	0	0%	0%
Lite	1	12.5%	 12.5%
Ingen	0	0%	0%



## Hvor mye erfaring har du med VR?

Antall svar: 8

Svar	Antall	% av svar	
Veldig mye	1	12.5%	 12.5%
Mye	0	0%	0%
Noe	3	37.5%	 37.5%
Lite	3	37.5%	 37.5%
Ingen	1	12.5%	 12.5%




## Hvor mye erfaring har du med fiskeoppdrett?

Antall svar: 8

Svar	Antall	% av svar	
Veldig mye	0	0%	0%
Mye	0	0%	0%
Noe	0	0%	0%
Lite	2	25%	 25%
Ingen	6	75%	 75%

## Kjønn

Antall svar: 8

Svar	Antall	% av svar	
Ønsker ikke å oppgi	0	0%	0%
Annet	1	12.5%	 12.5%
Kvinne	1	12.5%	 12.5%
Mann	6	75%	 75%

## Alder

• 24

• 30

• 15

• 29

• 25

• 24

• 23

• 23

## Jeg likte å bruke applikasjonen.

Antall svar: 8

Svar	Antall	% av svar	
Svært uenig	0	0%	0%
Litt uenig	0	0%	0%
Verken enig eller uenig	0	0%	0%
Ganske enig	1	12.5%	12.5%
Svært enig	7	87.5%	87.5%

## Det var lett å bruke applikasjonen.

Antall svar: 8

Svar	Antall	% av svar	
Svært uenig	0	0%	0%
Litt uenig	0	0%	0%
Verken enig eller uenig	0	0%	0%
Ganske enig	3	37.5%	37.5%
Svært enig	5	62.5%	62.5%

## Brukervennlighet



## Jeg tenker at jeg vil bruke appen regelmessig.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	2	25%	25%
3	1	12.5%	12.5%
2	1	12.5%	12.5%
1	4	50%	50%

## Jeg synes appen er unødvendig kompleks.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	1	12.5%	12.5%
1	7	87.5%	87.5%






## Jeg synes appen var enkel å bruke.

Antall svar: 8

Svar	Antall	% av svar	
5	6	75%	75%
4	1	12.5%	12.5%
3	1	12.5%	12.5%
2	0	0%	0%
1	0	0%	0%



## Jeg tror jeg vil trenge støtte fra en veileder som forklarer hva jeg skal gjøre for å bruke appen på riktig måte.

Antall svar: 8

Svar	Antall	% av svar	
5	1	12.5%	 12.5%
4	1	12.5%	 12.5%
3	3	37.5%	 37.5%
2	2	25%	 25%
1	1	12.5%	 12.5%




## Jeg synes appens funksjoner er godt integrert.

Antall svar: 8

Svar	Antall	% av svar	
5	6	75%	 75%
4	2	25%	 25%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Jeg synes det var for lite logisk sammenheng i appen.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	1	12.5%	 12.5%
3	0	0%	0%
2	1	12.5%	 12.5%
1	6	75%	 75%

## Jeg kan tenke meg at de fleste lærer seg å bruke appen svært raskt.

Antall svar: 8

Svar	Antall	% av svar	
5	4	50%	50%
4	4	50%	50%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Jeg synes appen er veldig tungvin å bruke.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	4	50%	50%
1	4	50%	50%

## Jeg følte meg veldig trygg på å bruke appen.

Antall svar: 8

Svar	Antall	% av svar	
5	4	50%	50%
4	3	37.5%	37.5%
3	1	12.5%	12.5%
2	0	0%	0%
1	0	0%	0%

## Jeg trengte å lære mye før jeg kunne komme i gang med denne appen.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	1	12.5%	12.5%
3	3	37.5%	37.5%
2	1	12.5%	12.5%
1	3	37.5%	37.5%

## Opplevelse

### Jeg opplevde ubehag da jeg brukte appen.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	2	25%	25%
1	6	75%	75%

### Jeg ble kvalm da jeg brukte appen.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	0	0%	0%
1	8	100%	100%

## Jeg ble sliten i øynene av å bruke appen.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	1	12.5%	12.5%
3	0	0%	0%
2	2	25%	25%
1	5	62.5%	62.5%

## Jeg synes det var gøy å bruke appen.

Antall svar: 8

Svar	Antall	% av svar	
5	7	87.5%	87.5%
4	1	12.5%	12.5%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Jeg synes en slik type app er veldig interessant.

Antall svar: 8

Svar	Antall	% av svar	
5	4	50%	50%
4	3	37.5%	37.5%
3	0	0%	0%
2	1	12.5%	12.5%
1	0	0%	0%

## Oppgavene i appen greide ikke å holde oppmerksomheten min.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	1	12.5%	12.5%
3	0	0%	0%
2	2	25%	25%
1	5	62.5%	62.5%

## Jeg tror det har verdi for meg å bruke en slik app.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	1	12.5%	12.5%
3	1	12.5%	12.5%
2	2	25%	25%
1	4	50%	50%





## Jeg kunne tenkt meg å brukt en slik app igjen fordi det ville hatt verdi for meg.

Antall svar: 8

Svar	Antall	% av svar	
5	0	0%	0%
4	1	12.5%	12.5%
3	1	12.5%	12.5%
2	2	25%	25%
1	4	50%	50%




## Jeg lærte mye om fiskevelferd når jeg brukte appen.

Antall svar: 8

Svar	Antall	% av svar	
5	1	12.5%	 12.5%
4	3	37.5%	 37.5%
3	2	25%	 25%
2	2	25%	 25%
1	0	0%	0%





## Jeg har fått en grunnleggende forståelse for hvordan lusetelling gjennomføres.

Antall svar: 8

Svar	Antall	% av svar	
5	2	25%	 25%
4	5	62.5%	 62.5%
3	1	12.5%	 12.5%
2	0	0%	0%
1	0	0%	0%





## Jeg kan bruke det jeg lærte i appen i et virkelig scenario.

Antall svar: 8

Svar	Antall	% av svar	
5	2	25%	 25%
4	3	37.5%	 37.5%
3	0	0%	0%
2	1	12.5%	 12.5%
1	2	25%	 25%





## Jeg tror jeg kunne gitt en god forklaring av lusetellingsprosessen til en medstudent eller kollega

Antall svar: 8

Svar	Antall	% av svar	
5	2	25%	 25%
4	4	50%	 50%
3	1	12.5%	 12.5%
2	1	12.5%	 12.5%
1	0	0%	0%





## Jeg er sikker på at jeg kan forstå koseptene presentert i appen.

Antall svar: 8

Svar	Antall	% av svar	
5	3	37.5%	 37.5%
4	3	37.5%	 37.5%
3	0	0%	0%
2	1	12.5%	 12.5%
1	1	12.5%	 12.5%

## Jeg er sikker på at jeg kunne gjennomført oppgavene jeg lærte i appen.

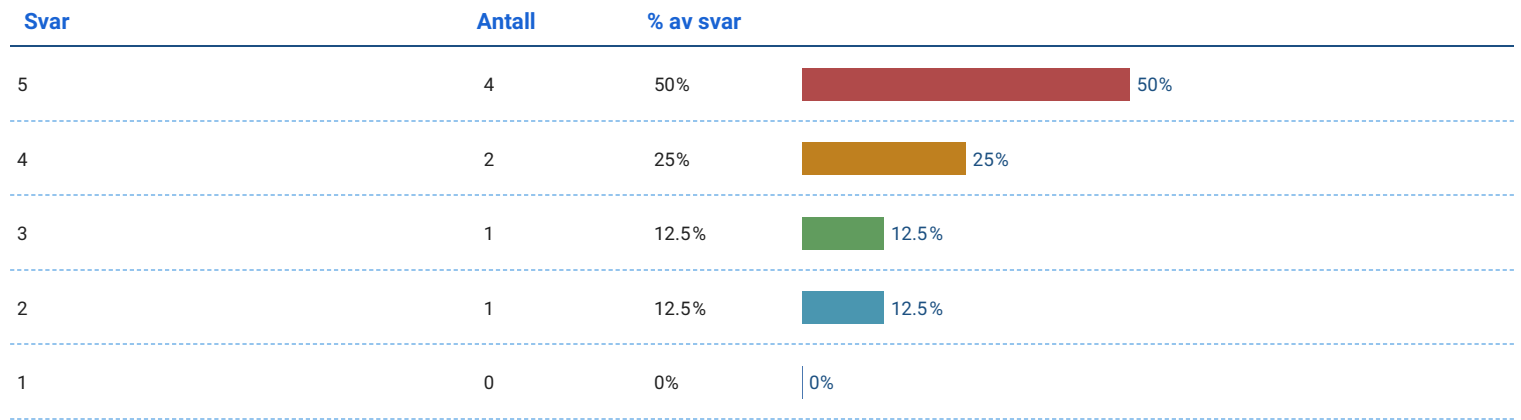
Antall svar: 8

Svar	Antall	% av svar	
5	2	25%	 25%
4	3	37.5%	 37.5%
3	2	25%	 25%
2	0	0%	0%
1	1	12.5%	 12.5%



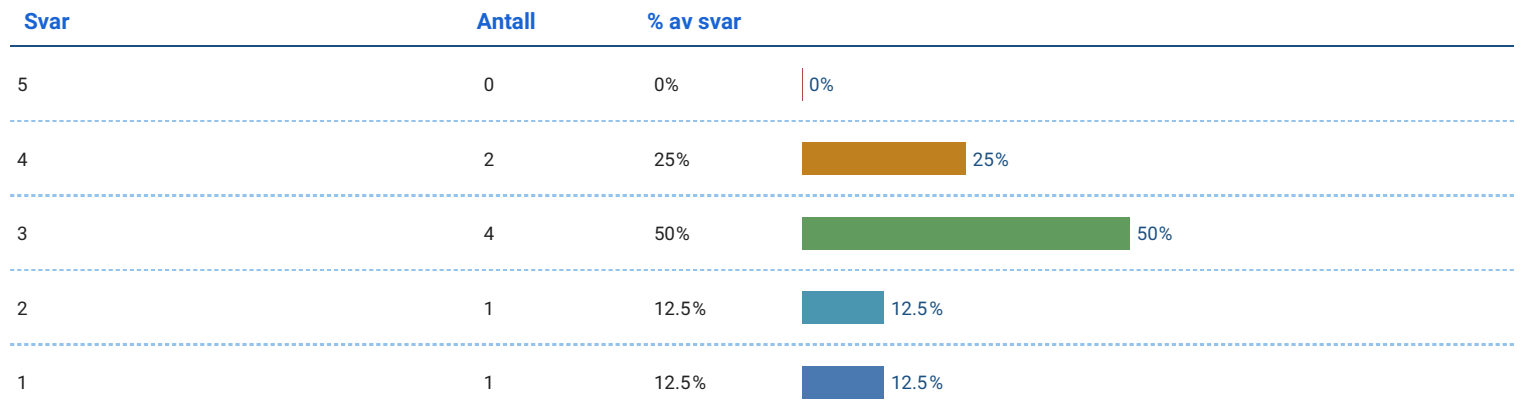
## Jeg føler jeg har lært noe om fiskeoppdrett etter å prøvd appen.

Antall svar: 8



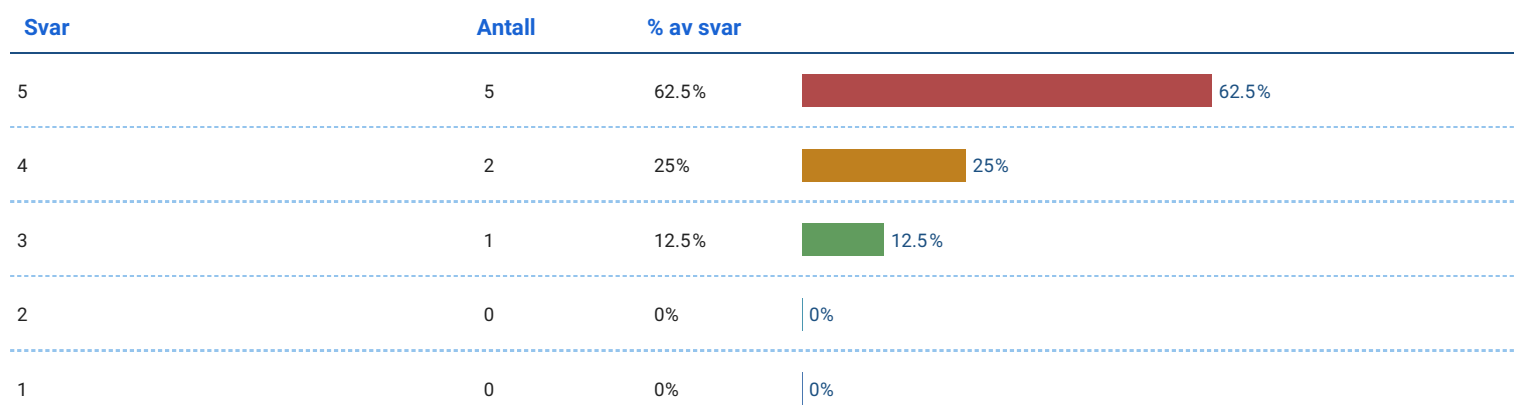
## Jeg er mer interessert i fiskeoppdrett etter å ha prøvd appen.

Antall svar: 8







## Jeg syns omgivelsene var realistiske.

Antall svar: 8







## Jeg syns fisken så og oppførte seg realistisk.

Antall svar: 8

Svar	Antall	% av svar	
5	2	25%	 25%
4	4	50%	 50%
3	1	12.5%	 12.5%
2	1	12.5%	 12.5%
1	0	0%	0%

## Jeg prøvde å behandle fisken med respekt.

Antall svar: 8

Svar	Antall	% av svar	
5	2	25%	 25%
4	2	25%	 25%
3	1	12.5%	 12.5%
2	0	0%	0%
1	3	37.5%	 37.5%

## Til slutt...

### Hvordan var det å håndtere fisken?

- Stort sett greit, men av og til sprelte den på litt brått og urealistisk vis. Synes ikke at det å snu den var så lett. Var også et par ganger at jeg skulle legge den på bordet, og så hørte jeg en klaskelyd som jeg ikke skjønnte hvor kom fra.
- Det fungerte fint, men jeg var nødt til å legge fisken på bordet for å undersøke.
- Lett og flotte detaljerte modeller
- Det var veldig gode kontroller og fisken bevegde seg veldig naturlig. Klarte å glitche den litt, men det må være ganske umulig å unngå. Gøy at den hadde lyd når du klasket den i bordet, men det insentiverte mishandling av fisken som kanskje ikke er så heldig. Fine og naturtro modeller av fisken.
- Litt vanskelig å behandle fisken riktig mellom stasjon til stasjon
- Lettvint
- Jeg prøvde å holde den så da sprelte den litt rundt. Men det var lettere å ha den liggende på bordet. Det var bra å håndtere fisken
- Litt knotete, men nå er det kanskje sånn i virkeligheten og, usikker på hvor sterkt de blir bedøvet. Hadde vært fint om det var mulig å ta tak i gjellene for å se mer nøye etter misfarging.

## Hvordan var det å telle lus?

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- Det gikk greit, selv om det var noen jeg overså.
- De var godt synlige og enkle å telle.
- Litt vanskelig å se alltid
- Det gikk veldig fint, det var et par tilfeller jeg var usikker på om det var lus eller bare en flekk. Det var noen ganger det virket som at lusen tydelig stakk ut av modellen til fisken, mens andre ganger ikke. Det var litt vanskelig å vite om begge tilfellene var reelle lus.
- Gikk greit, men hadde litt problemer på grunn av litt utydelige bilder (ikke justert brillene korrekt)
- Uvant
- Telle lus var enkelt og bra.
- Litt vanskelig, var usikker på hva som var sår og hva som var lus. Hadde kanskje vært fint å lære brukeren litt mer om hvordan lus vs sår vanligvis ser ut før man må kategorisere dem.

## Hvordan var det å se etter sykdom på gjellene?

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- Hadde ikke en god forståelse for hva jeg skulle se etter. Fikk litt informasjon før jeg starta, men hvis jeg hadde starta spillet "blindt" hadde jeg ikke hatt noen anelse om hvordan gjellesykdommer ser ut (men nå jobber jo ikke jeg i industrien heller). Jeg syntes dermed også at det var vanskelig å plassere alvorlighetsgraden på en skala, siden jeg ikke visste hvordan hver ende i skalaen skulle se ut.
- Det var litt vanskelig uten et referansepunkt (hvordan friske gjeller ser ut). Men ellers var gjellene og fargen godt synlig.
- Vanskelig når man ikke vet så mye fra før
- Det var veldig vanskelig. Følte ikke jeg hadde nok kunnskap på forhånd for å vite hva jeg så etter. Resultatet ble at alle fiskene virket som de hadde sykdom siden jeg ble fortalt at friske gjeller var rosa og fine, mens alle gjellene var mørkebrune og grumsete. Et forslag er å vise en modell med friske og syke gjeller før testen og ikke bare forklare med en vegg av tekst. Dette mediet støtter veldig fint dette. Å vise modeller på forhånd kan også gjøre det tydeligere med hva som er lus og ikke.
- Opplevdes som vanskelig, men mest på grunn av at jeg ikke har noe særlig referanse på hvordan friske gjeller ser ut
- Vanskelig siden jeg ikke visste hva jeg så etter
- Det var litt verre. SKjønte ikke at man faktisk måtte se inn i gjellene og se etter misfarging der. Hadde vært kjekt med referanse bilder som viste hvordan gjellene skal se ut og ikke se ut.
- Også vanskelig, aner ikke hvordan syke gjeller ser ut. Visuelle examples først please :)

# Fiskevelferd - brukertest - utvidet - studenter

Oppdatert: 10. juni 2023 kl. 23:34

## Bakgrunn

Skriv inn nummeret du ble tildelt.

• 2

• 1

## Hvor mye erfaring har du med dataspill?

Antall svar: 2

Svar	Antall	% av svar	
Veldig mye	2	100%	<div style="width: 100%;"><div style="width: 100%;"></div></div> 100%
Mye	0	0%	<div style="width: 0%;"></div> 0%
Noe	0	0%	<div style="width: 0%;"></div> 0%
Lite	0	0%	<div style="width: 0%;"></div> 0%
Ingen	0	0%	<div style="width: 0%;"></div> 0%

## Hvor mye erfaring har du med VR?

Antall svar: 2

Svar	Antall	% av svar	
Veldig mye	0	0%	<div style="width: 0%;"></div> 0%
Mye	0	0%	<div style="width: 0%;"></div> 0%
Noe	0	0%	<div style="width: 0%;"></div> 0%
Lite	2	100%	<div style="width: 100%;"><div style="width: 100%;"></div></div> 100%
Ingen	0	0%	<div style="width: 0%;"></div> 0%

## Hvor mye erfaring har du med fiskeoppdrett?

Antall svar: 2

Svar	Antall	% av svar	
Veldig mye	0	0%	0%
Mye	0	0%	0%
Noe	0	0%	0%
Lite	0	0%	0%
Ingen	2	100%	100%

## Kjønn

Antall svar: 2

Svar	Antall	% av svar	
Ønsker ikke å oppgi	0	0%	0%
Annet	0	0%	0%
Kvinne	0	0%	0%
Mann	2	100%	100%

## Hvor gammel er du

• 24

• 23

## Jeg likte å bruke applikasjonen.

Antall svar: 2

Svar	Antall	% av svar	
Svært uenig	0	0%	0%
Litt uenig	0	0%	0%
Verken enig eller uenig	0	0%	0%
Ganske enig	2	100%	100%
Svært enig	0	0%	0%

## Det var lett å bruke applikasjonen.

Antall svar: 2

Svar	Antall	% av svar	
Svært uenig	0	0%	0%
Litt uenig	0	0%	0%
Verken enig eller uenig	1	50%	50%
Ganske enig	1	50%	50%
Svært enig	0	0%	0%

## Brukervennlighet

### Jeg tenker at jeg vill bruke appen regelmessig.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	1	50%	50%
2	1	50%	50%
1	0	0%	0%

### Jeg synes appen er unødvendig kompleks.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	0	0%	0%
2	1	50%	50%
1	0	0%	0%

## Jeg synes appen var enkelt å bruke.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	0	0%	0%
2	1	50%	50%
1	0	0%	0%

## Jeg tror at jeg ville trenge støtte fra en veileder som forklarer hva jeg skal gjøre for å bruke appen på riktig måte.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	0	0%	0%
2	1	50%	50%
1	0	0%	0%

## Jeg synes appens funksjoner er godt integrert.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	1	50%	50%
2	0	0%	0%
1	0	0%	0%

## Jeg synes det var for lite logisk sammenheng i appen.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	1	50%	50%
1	1	50%	50%

## Jeg kan tenke meg at de fleste ville lære å bruke appen svært raskt.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	0	0%	0%
2	1	50%	50%
1	0	0%	0%

## Jeg synes appen er veldig tungvint å bruke.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	1	50%	50%
2	1	50%	50%
1	0	0%	0%



## Jeg følte meg veldig trygg på å bruke appen.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	0	0%	0%
2	1	50%	50%
1	0	0%	0%

## Jeg trengte å lære mye før jeg kunne komme i gang med denne appen.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	1	50%	50%
2	0	0%	0%
1	1	50%	50%

## Opplevelse

### Jeg opplevde ubehag da jeg brukte appen.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	0	0%	0%
1	2	100%	100%

## Jeg ble kvalm da jeg brukte appen.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	0	0%	0%
1	2	100%	100%

## Jeg ble sliten i øynene av å bruke appen.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	0	0%	0%
2	0	0%	0%
1	2	100%	100%

## Jeg synes det var gøy å bruke appen.

Antall svar: 2

Svar	Antall	% av svar	
5	2	100%	100%
4	0	0%	0%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Jeg syns en slik type app er veldig interessant.

Antall svar: 2

Svar	Antall	% av svar	
5	1	50%	50%
4	1	50%	50%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Oppgavene i appen greide ikke å holde oppmerksomheten min.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	1	50%	50%
2	0	0%	0%
1	1	50%	50%

## Jeg tror det har verdi for meg å bruke en slik app.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	1	50%	50%
2	1	50%	50%
1	0	0%	0%

## Jeg kunne tenkt meg å brukt en slik app igjen fordi det ville hatt verdi for meg.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	0	0%	0%
2	0	0%	0%
1	1	50%	50%

## Jeg lærte mye om fiskevelferd når jeg brukte appen.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	0	0%	0%
2	1	50%	50%
1	0	0%	0%

## Jeg har fått en grunnleggende forståelse for hvordan lusetelling gjennomføres.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	2	100%	100%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Jeg kan bruke det jeg lærte i appen i et virkelig scenario.

Antall svar: 2

Svar	Antall	% av svar	
5	1	50%	50%
4	1	50%	50%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Jeg tror jeg kunne gitt en god forklaring av lusetellingsprosessen til en medstudent eller kollega

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	1	50%	50%
2	0	0%	0%
1	0	0%	0%

## Jeg er sikker på at jeg kan forstå koseptene presentert i appen.

Antall svar: 2

Svar	Antall	% av svar	
5	1	50%	50%
4	1	50%	50%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Jeg er sikker på at jeg kunne gjennomført oppgavene jeg lærte i appen.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	0	0%	0%
3	2	100%	100%
2	0	0%	0%
1	0	0%	0%

## Jeg føler jeg har lært noe om fiskeoppdrett etter å prøvd appen.

Antall svar: 2

Svar	Antall	% av svar	
5	2	100%	100%
4	0	0%	0%
3	0	0%	0%
2	0	0%	0%
1	0	0%	0%

## Jeg er mer interessert i fiskeoppdrett etter å ha prøvd appen.

Antall svar: 2

Svar	Antall	% av svar	
5	1	50%	50%
4	0	0%	0%
3	1	50%	50%
2	0	0%	0%
1	0	0%	0%

## Jeg syns omgivelsene var realistiske.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	1	50%	50%
2	0	0%	0%
1	0	0%	0%

## Jeg syns fisken så og oppførte seg realistisk.

Antall svar: 2

Svar	Antall	% av svar	
5	0	0%	0%
4	1	50%	50%
3	0	0%	0%
2	1	50%	50%
1	0	0%	0%

## Jeg prøvde å behandle fisken med respekt.

Antall svar: 2

Svar	Antall	% av svar	
5	1	50%	50%
4	0	0%	0%
3	0	0%	0%
2	1	50%	50%
1	0	0%	0%

Til slutt...

## Hvordan var det å håndtere fisken?

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- Greit, men teleportering fikk meg til å slå til fisken.
- Det var vanskelig, men ikke umulig.

## Hvordan var det å telle lus?

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- Jeg fikk ikke med meg mange
- Svært vanskelig. Jeg klarte ikke å se lusene ordentlig.

## Hvordan var det å se etter sykdom på gjellene?

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- Jeg hadde ikke noen referanse for score 1 og 5
- Veldig vanskelig! Kommer trolig av lite erfaring med erfaring av fiskesykdom.





 **NTNU**

Norwegian University of  
Science and Technology