Virtual reality-assisted competence recognition – supporting the employment of immigrants to the care industry

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Abstract

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This thesis, conducted as a part of a larger research and development project, VR Fast Track, examines how virtual reality (VR)-assisted competence recognition could support the employment of immigrants to vocational jobs. The topic is approached as a whole and through an example from the care industry.

The thesis' focus is twofold: first, examining what kind of a framework for competence recognition is most suited to structuring competences that are required in vocational jobs. Second, using this framework to generate sample use cases for VR-assisted competence recognition tasks and assessing whether such use of VR is advantageous and feasible generally and for project purposes.

An iterative service design approach was used to organize the various empirical activities executed to meet these goals. These included non-formal literature reviews on existing learning taxonomies, national competence requirements, and VR; expert interviews and workshops to collect information and validate study outputs; and hands-on testing of off-the-shelf VR solutions and software.

It was concluded that existing learning taxonomies did not meet the needs of the VR Fast Track project, so a new general competence recognition framework was built. Care-specific competence examples were then incorporated to the framework. Based on these outputs, a curriculum of VR use cases was outlined and one use case detailed to the level of implementation readiness. Moreover, a VR use case template was created, as well as a process demonstrating the use of the framework in connection with the use cases.

The thesis concluded that while VR has potential in enabling competence recognition in realistic scenarios that are not overly dependent on language skills, using off-the-shelf VR technology is not yet feasible when complex features such as interaction or multisensory experiences are required. Therefore, it is more feasible for VR Fast Track to use a lightweight VR method, such as 360° videos, whose implementation is simple, and which can also be utilized via non-VR channels. This enables the wider-scale collection of stakeholder feedback that is essential for the future development of all the thesis outputs.

Keywords
Competence recognition, Virtual reality, Use case, Employment support

Table of contents

1 Introduction

This thesis examines how virtual reality (VR)-assisted competence recognition could help in supporting and speeding up the employment of immigrants to the care industry in Finland. The study is a part of an ongoing research and development (R&D) project in Haaga-Helia University of Applied Science (UAS), VR Fast Track (VR Fast Track 2019).

The purpose of this thesis is to create an industry-independent general competence recognition framework and a draft of its application to the care industry. A competence recognition framework is a structure that defines individual competences required to perform at work and their relation to each other. Case examples of competence recognition tasks to be later implemented in a VR environment are composed based on the framework. The competence recognition frameworks and the examples composed in this study can be extended to other industries and competence levels in further research.

The VR Fast Track project proposes that the benefits of using virtual environments should be studied with immigrants who lack skills in the official languages of Finland and may therefore struggle to illustrate their competences with other, often verbally oriented methods (VR Fast Track 2019). The project posits that jobs that do not initially require advanced language skills may be found in various fields. This thesis examines competence requirements through a care industry example, focusing on supporting function positions that do not require formal education, such as keeping customers company and taking them outdoors.

The main outputs of this thesis are the general competence recognition framework, its example application to the care industry, a use case ready for VR implementation, and a use case template designed for future use in VR-assisted competence recognition. A library structure of competence recognition tasks to help build curriculums for different fields is also outlined on a high level.

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1.1 VR Fast Track project

This thesis is part of an ongoing R&D project, VR Fast Track, conducted jointly by Haaga-Helia and Turku UAS. The aim of the VR Fast Track project is to develop a competence recognition model utilizing VR for company use. Companies can use this model and the resulting VR tasks to recognize general and industry-specific competences to fast track employment – especially the employment of immigrants. Immigrants are the target group as the project hypothesizes that VR tools could be better suited for competence recognition where other competence recognition methods are prevented by language barriers. (VR Fast Track 2019)

The project's participants and their roles are illustrated in the stakeholder map in Figure 1, which also shows how this thesis supports the project. The project is a collaboration between the UASs, partner companies and immigrant organizations. Partner companies act as sources of industry specific requirements and knowledge. Partner companies intend to hire employees based on the successful completion of the competence recognition tasks. Immigrant organizations provide expertise related to immigrants' employment, as well as locating employee candidates and testers for the VR implementations. (VR Fast Track 2019)

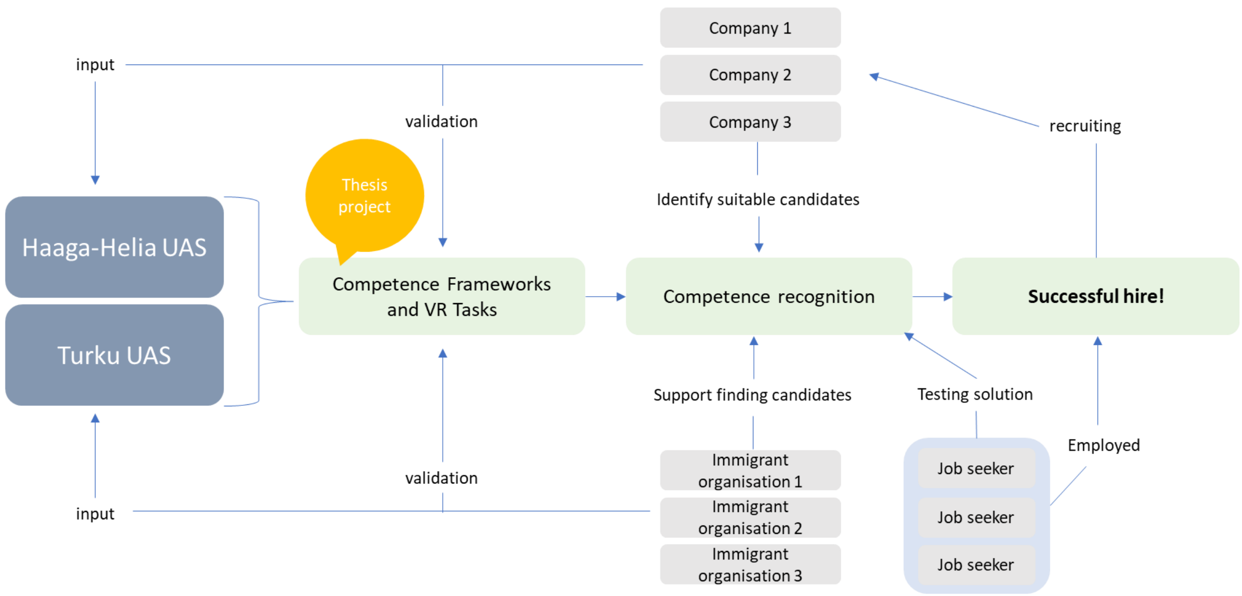

Figure 1. The stakeholder map of the VR Fast Track project, including the role of this thesis.

The customer of this thesis is the VR Fast Track project team. This study's goal is to support the VR Fast Track project by delivering a competence recognition framework and competence recognition task descriptions for later VR implementation by the project. Due to the iterative and experimental nature of the work it is likely that the VR Fast Track project team will continue to further develop these outputs after the thesis has been finalized.

1.2 Target group

This study serves multiple target groups. First, the VR Fast Track project is the main user of its outputs. Second, the competence recognition frameworks and the VR task use cases serve the hiring companies. Third, job seekers are the end users of the eventual VR tasks.

One of the goals of the VR Fast Track project is to support the employment of immigrants in Finland (VR Fast Track 2019). People might relocate for various reasons, and immigrants settling to Finland represent many cultures and backgrounds. The target group of this study is therefore further narrowed down to immigrants with limited elementary school tuition and no higher education. It is thought that this target group would benefit from demonstrating their skills in concrete VR scenarios as opposed to describing them verbally.

Integrating immigrants to the labor market is a European Union (EU)-wide challenge with impacts on overall social wellbeing and inter-ethnic relations as well as economic growth. The benefits of successful integration of the immigrants could help to solve the EU-wide labor shortage in some industries and help all people living in the EU region to utilize their full capabilities. (Lodigiani, Sarli 2017)

This study focuses on the care industry as specified by the VR Fast Track project. The target roles to be filled involve tasks that do not require formal qualification (e.g. practical nurse, nurse). Examples of such supporting functions include aiding with daily functions, conversation, and outings. The purpose of the competence recognition framework and the VR tasks is to aid the recruitment process by demonstrating the care industry-related competences job seekers might already possess. However, the competence recognition outputs of this study should first be developed further, then be used to support the recruitment process, not as standalone tests.

Based on the research interviews conducted during this study, the main immigrant group to benefit from VR-assisted competence recognition in terms of finding employment are people whose reading, writing, and numerical skills are deficient due to lack of education. Specifically, their skills in the official languages of Finland may be lacking. The hypothesis of the VR Fast Track project is that this group of immigrants could potentially benefit most from VR-assisted competence recognition, since it could provide a concrete way of demonstrating competences (VR Fast Track 2019). People with advanced language skills and formal education can perhaps more easily follow conventional recruitment paths. This target group's limitations in technical experience and specifically concerning VR must of course also be considered. There is a risk that technical challenges and the learning process of using VR equipment supersedes the actual competence recognition.

1.3 Objectives

The following objectives were defined by the VR Fast Track project at the beginning of the thesis project:

1. Compose a synthesis framework for competence recognition based on existing taxonomies with a focus on vocational work
(European Qualifications Framework levels 1 to 4)

2. Specify care industry-specific competences for target roles and incorporate them to the composed framework

3. Define sample use cases for VR-assisted competence recognition based on the created framework for implementation purposes

4. Assess the benefits and the feasibility of using VR in competence recognition in general and for the specific use cases created in the project

1.4 Research questions

The research questions in Table 1 are derived from the numbered project objectives presented in section 1.3.

Table 1. Research questions for the project.

Objective	**Research question(s)**
1	RQ 1: What competence recognition taxonomy or framework is most suited to project purposes? RQ 1.1 What are the existing taxonomies? RQ 1.2 What are the pros and cons of existing taxonomies?

	RQ 1.3 Can an existing taxonomy be used directly, or is a synthesis required to build a framework for project purposes? RQ 1.4 If required, what is the best way to synthesize existing taxonomies to build a framework for project purposes?
2	RQ 2: What are the competences for target roles specified by partner companies? RQ 2.1 What are industry-specific competences for care? RQ 2.2 What, if any, are industry-independent competences?
3	RQ 3: How should use cases for VR implementation be composed?
4	RQ 4: What, if any, is the advantage of using VR in competence recognition in general and for project purposes?
5	RQ 4: How feasible is the implementation of the composed VR use cases?

1.5 Delimitation

The objectives and research questions presented in the previous sections outline the project's aims. Due to the iterative and changing nature of the R&D project, detailed and static delimitation was not possible to begin with. However, some limits were defined to protect the thesis from scope creep.

The implementation of the composed use cases in a VR environment was out of scope. The same applied to the scoring of use case execution by means of building a so-called user competence profile.

In assessing the feasibility of implementing the composed use cases, implementation cost calculations and technical analysis was out of scope.

Validation of project outputs was limited in such a way that it was provided mainly by the VR Fast Track Project team. The care industry-specific competence framework was reviewed by a VR Fast Track partner company. These limitations were due to the coronavirus (COVID-19) pandemic that occurred during the thesis.

2 Study design and execution

This section describes the methodology employed in this pair work thesis. It also recounts the main events of the study process, since its agile and iterative properties were a notable factor in all phases of the work. Finally, ethical issues are discussed.

2.1 Development strategy

The study's goals, collaborators, timetables, and resources were, to some degree, defined by the parent R&D project, VR Fast Track. Many of these factors were prone to change. This study was therefore required to quickly adapt to changes, which made an agile approach to project management the most relevant choice (Wysocki 2012). Concrete tasks and their allocation were specified and adjusted as the project progressed. With a pair project, equal distribution of work was crucial, and this was ensured by frequent mutual contact and agreement. Progress was monitored by the authors in weekly check points, at a minimum. Additionally, the authors communicated via email, telephone, and Microsoft Teams. Project steering group meetings were held monthly.

The work was performed iteratively based on an applied implementation of the Plan-Do-Check-Act (PDCA) method. The general outlines of the development strategy are portrayed in Figure 2. First, the tasks next in line were identified, planned, and prioritized. Literature and other sources were studied to allow task execution. Most tasks involved some form of data collection, the details of which are described later. Learnings were then analyzed and used to generate study outputs, which were validated with the VR Fast Track project or its partners. In many cases some of these steps partially overlapped, making constant goal adjustment necessary.

Figure 2. The study's overall development strategy.

2.2 Design method

Service design was used as the study's design method. Miller (2015) proposes the following definition for service design:

> *"Service design helps organizations see their services from a customer perspective. It is an approach to designing services that balances the needs of the customer with the needs of the business, aiming to create seamless and quality service experiences. Service design is rooted in design thinking, and brings a creative, human-centered process to service improvement and designing new services. Through collaborative methods that engage both customers and service delivery teams, service design helps organizations gain true, end-to-end understanding of their services, enabling holistic and meaningful improvements."*

Service design is not a traditional academic research method. It can be viewed as a mindset, a process, a toolset, or a cross-disciplinary language – but in practice it is a combination of these elements, adapted to different situations (Stickdorn, Hormess et al. 2018). Service design was selected as the study's research approach because it offered a framework for understanding and organizing the various empirical activities of this non-traditional R&D thesis. The six core principles of service design, as defined by Stickdorn et al.

(2018), befitted the thesis. The six principles are depicted in Figure 3, and how each of them was taken into account in this thesis is described below.

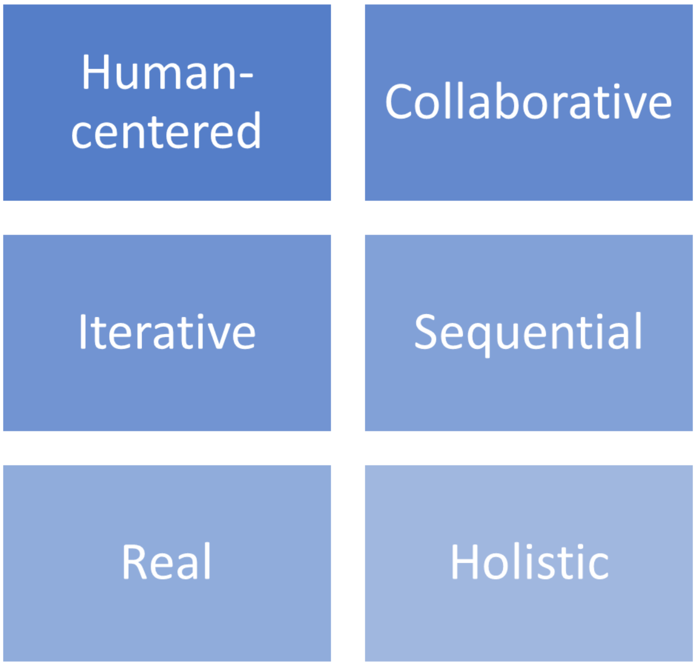

Figure 3. The six service design principles. Adapted from (Stickdorn, Hormess et al. 2018).

First, the project was *human-centered*, and it had a strong link to real life, focusing on the needs of job seekers as well as companies in need of appropriately skilled workforce. Second, the thesis produced concrete outputs for the VR Fast Track project, which could use them to create *real-world value* for its participants. Third, the project was *collaborative*, as input was actively sought from a variety of stakeholders. Fourth, the work was adaptive, exploratory, and *iterative*, both within this thesis and its parent R&D project context. Figure 2 illustrates how iteration was inbuilt to the thesis' project management. The outputs were created and reviewed with stakeholders in segments, and the intention was that they would be developed further after this study. Fifth, the principle of *sequencing* was utilized in creating the outputs: the different parts link together to form an interrelated whole, from the competence recognition frameworks to the detailed VR use case descriptions. Finally, a *holistic* view was formed of the real-world contexts where the study outputs would be used: for instance, use cases were designed in such a way as to be quickly usable during a recruitment session.

Stickdorn et al. (2018) differentiate between concrete service design *tools*, and *methods*, which are procedures to accomplish something, such as conducting interviews to collect data. The list below presents the service design tools that were used in the thesis. The definitions follow Stickdorn et al. (2018). After the list, this chapter continues by describing the study's data collection methods.

- Personas
    - Definition: a research-based archetype of a stakeholder group.
    - Usage in the thesis: stakeholder input was collected to develop a profile of the VR task end users.
- Stakeholder maps
    - Definition: an illustration of stakeholders' relationships and roles.
    - Usage in the thesis: mapping the various stakeholders and understanding their roles in the project.
- User stories
    - Definition: a summary of requirements to an IT system, written from a user's perspective and in natural language.
    - Usage in the thesis: first user story drafts were written separately, but later the stories were included into the VR use cases to underline their user centricity.
- Prototypes
    - Definition: an early form of something, used to explore and evaluate ideas with stakeholders.
    - Usage in the thesis: all study outputs underwent several iterations. The first prototypes were tested among the authors, and later in collaboration with relevant stakeholders.
- Electronic mind maps
    - Definition: a visual, updating arrangement of ideas and notes.
    - Usage in the thesis: an internal project management utility to help coordinate the agile process.

2.3 Data collection and analysis

Data collection occurred between March and September 2020. To collect data, a variety of methods were used. These are listed below with a description of how said method was used in this thesis.

- Literature reviews
    - Usage in the thesis: examining existing learning taxonomies, the national competence requirements for potential target industries, and the basics of VR. However, a formal literature review was not performed.

- Expert interviews and workshops.
    - Usage in the thesis: collecting information and/or study output validation from the following subject matter specialists: experts of the VR Fast Track project, a representative of the Ministry of Education and Culture, representatives of an immigration organization, a VR specialist, and representatives of care industry partner companies. The use of this method is described in more detail in the body of this section.
- E-mail information requests to experts.
    - Usage in the thesis: a European commission specialist was consulted to understand how Finland validates non-formal learning. Since the query was simple, an interview was not required.
- Studying the basics of use case and script writing through online sources and books.
    - Usage in the thesis: understanding the state of the practice and how best to compose VR use cases. Non-VR IT use case writing was used as the starting point for this examination.
- Studying the basics of VR content design and creation through online sources and books.
    - Usage in the thesis: understanding what needed to be considered in creating use cases for VR. Service design and human-centered design were the main approaches to this task.
- Hands-on testing of existing VR implementations for the consumer market.
    - Usage in the thesis: examining the state of the practice in off-the-shelf VR and gaining subjective empirical knowledge of what using VR feels like. Different VR solutions were tested. A standalone Oculus Quest HMD was used for testing.
- Hands-on testing of 3D Virtual Vista VR software.
    - Usage in the thesis: understanding how feasible lightweight 360° VR implementations currently are when using off-the-shelf software.

Expert interviews and workshops were used because information and feedback on a broad range of iteratively emerging and changing matters was needed during the study. It was therefore not feasible nor desirable to focus efforts on certain predetermined matters and, for instance, conduct a survey or a controlled experiment.

The expert interviews were mainly semi-structured, while some were more workshop-like in that they centered around reviewing study outputs. The semi-structured interviews were recorded, and informed consent was requested from the interviewees beforehand. The informed consent form is available in Appendix 1. An example of a semi-structured interview guide, used with experts from an immigration organization, is included in Appendix 2. The guide is in Finnish, as all the interviews and workshops were held in Finnish if no non-Finnish-speakers were present. This was done to allow for maximally natural and expressive communication. An interview guide was not devised for the workshops – in these cases, an agenda was outlined by the authors and the event was run according to it.

Participant selection for the interviews and workshops was purposeful, mainly using the parent project's ecosystem. If this was not sufficient, such as when collecting information on Finnish educational requirements in specific industries, other channels were sought by the authors.

Data collection restrictions occurred during the study due to the coronavirus pandemic and its countermeasures. This necessitated the use of all-virtual communication methods and prevented the organization of face-to-face interviews and workshops, which would have been the authors' primary choice in normal circumstances. Likewise, the authors were mainly obliged to co-work virtually. Virtual communication unavoidably limits the versatility and quality of interaction. Furthermore, access to libraries was prohibited for a notable period during the study, limiting the amount of available study material. This was especially troublesome with materials concerning learning taxonomies since electronic sources were scant. The implications of these data collection restrictions on research ethics are discussed further in section 2.5.

No specific data analysis method was used due to the nature of the study and the heterogeneity of the collected material. For instance, several interviews and workshops were carried out, but the objective was not to repeat a specific interview multiple times to reach data saturation. This restriction was necessary, since resources were limited and since the aim was not to conduct an actual interview study per se. More concrete descriptions of how collected data were used is found in connection with each section in this document that describe the study outputs.

2.4 Study process

The study's execution consisted of several iterations of various tasks. An overview is found in Figure 4. It shows the study's starting points, namely objectives and research questions. Of these, the research questions were refined during the project. Information sources were roughly separated into three sections: those concerning existing learning taxonomies, basic VR theory and its concrete possibilities in the VR Fast Track project, and requirements concerning the competences of job seekers. Based on this learning, several working documents were developed in the study. These were used to hone the final outputs, shown in bright green. These outputs were then summarized and passed on to Krea, a creative agency of the Haaga-Helia UAS (Krea 2020). Krea will develop them further in collaboration with the VR Fast Track project.

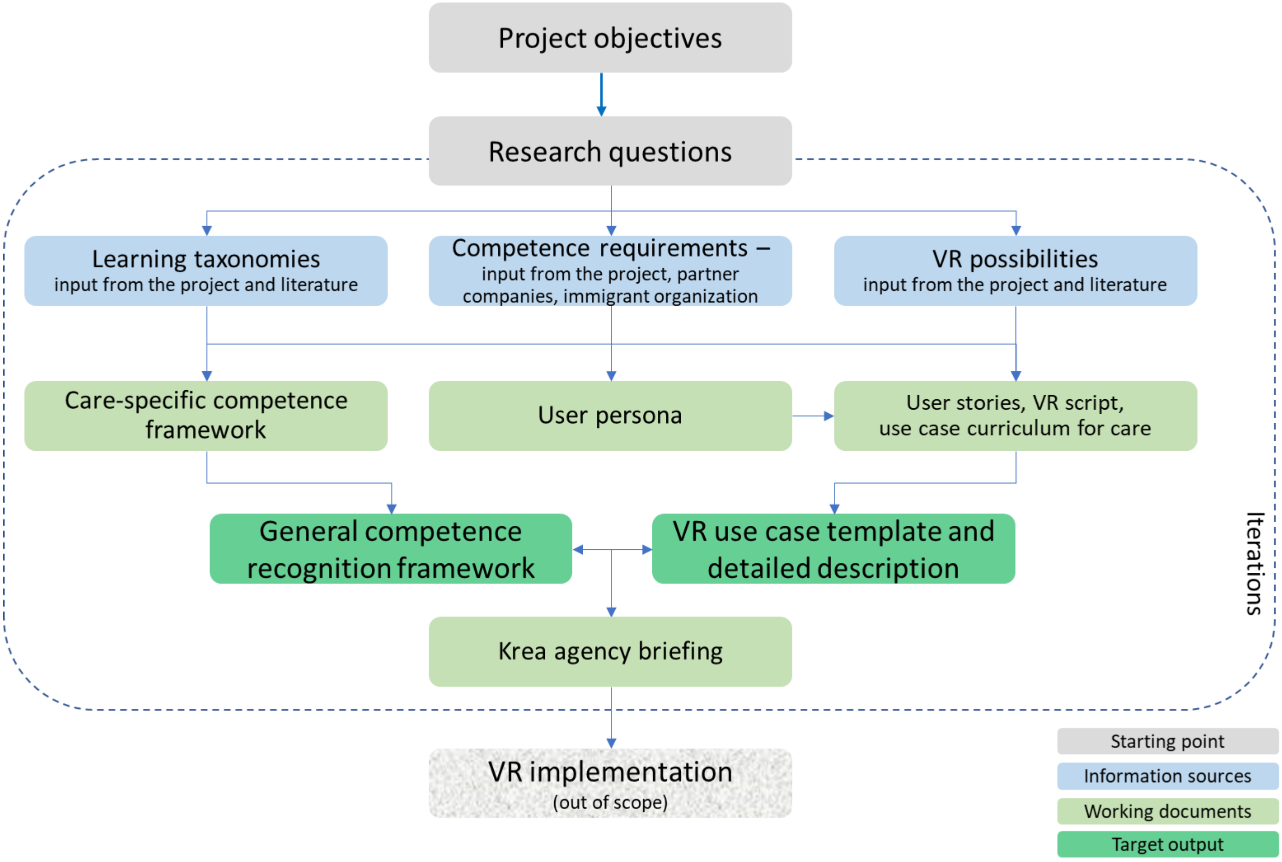

Figure 4. Study process overview.

The iterative approach allowed for such agility that was necessary in an R&D project, but it was somewhat work intensive. To demonstrate this, the authors kept a log of the major occurrences in this project. The log is available in Appendix 10.

2.5 Ethical considerations

According to the guidelines of the service design approach, all possible stakeholders were involved in ways that were feasible within limited project resources and the global state of emergency caused by the coronavirus. It was especially important to consult stakeholders since the authors were not experts in the subject areas of learning taxonomies, competence recognition, virtual reality, or the care industry. However, most collaborators, especially those within the care industry, were swamped with unexpected coronavirus-related work and were not able to contribute as planned. This led to some research ethical quandaries. These were mitigated by clearly informing the VR Fast Track project that some study outputs would have to be further developed to reach sufficient maturity. This is especially salient regarding the care-specific application of the competence recognition framework.

The study's target group was immigrants who have less formal education and weaker language skills in Finnish or Swedish and may therefore be at risk of being marginalized or discriminated against in the labor market. This focus was defined by the VR Fast Track project. The authors are not immigrants themselves nor professionals in this area, which exposed the study to research ethical issues. This called for sensitivity in all phases of the study. Notably, immigration experts were consulted to help steer the work. The premise in composing the study outputs was that all kinds of people, immigrant and non-immigrant alike, may have difficulties with skill verbalization and could thereby benefit from concrete competence recognition tasks. Moreover, people of all backgrounds perform assisting or vocational jobs, so there is also no inherent appraisal in limiting this study's efforts to the European Qualifications Framework's levels 1 to 4.

Since technical implementation was out of project scope, the possibilities for VR sickness in the produced use case examples was not empirically studied. However, they were designed with VR sickness prevention in mind; for instance, task duration was limited, and time to adjust to using a VR system was built in. Nevertheless, the implementation phase is most critical in this respect, and VR sickness incidence should be examined in future research, for instance using the Kennedy Simulator Sickness Questionnaire or one of its revisions.

3 Learning taxonomies

This section presents different taxonomy models to understand how competences can be classified and structured.

Competency is used to describe the desired skills and knowledge to successfully perform in work, education, and other contexts. Skills are specific activities learned to carry out tasks. Skills are practical, whereas knowledge is more theoretical. Knowledge refers to information and understanding. The relation between skills and knowledge can be viewed as skills being the application of knowledge. Whereas skills and knowledge can be very specific, competency is a broader concept. One competence can require the mastery of several skills and knowledge of different topics.

Competences are also often confused with learning outcomes, which are more specific statements describing what a student is be able to do in a measurable way. As learning outcomes are specific, there might be several linked to one competence.

This study focuses on competences, as the goal is to examine what competences individuals already have, as opposed to teaching them new ones.

Taxonomies are a useful way to reduce complexity and clarify the essential components of learning. Taxonomies serve as a tool to detect similarities and differences between the different goals. Taxonomies can be used to study relationships between concepts. Good taxonomies are versatile, and the presented categories are both exhaustive and mutually exclusive. (Bailey 1994)

This study focuses on formal qualifications frameworks such as the European Qualifications Framework (EQF) and the Finnish Qualifications Framework (FiNQF), Bloom's revised taxonomies, Marzano's New Taxonomy, and selected examples of more informal frameworks, namely Significant Learning and Six Facets of Understanding. The goal is to understand the usability of these models to see if they could be directly applied to the study's context or is either a synthesis or a completely new classification system required to reach the thesis objectives.

The taxonomies selected for examination are learning taxonomies. Learning taxonomies were chosen to understand the skills and competences people are expected to have on different educational levels, and how they relate to each other. Another reason for focusing on learning taxonomies was that taxonomies for pure competence recognition were not readily available.

3.1 Qualifications frameworks: EQF and FiNQF

The EQF is a general classification model used across the EU as a baseline for structuring different types of formal and non-formal learning. The FiNQF presents the Finnish education system and maps it to the EQF levels.

Both concepts were studied because the EQF is the umbrella concept that covers the EU region, while the FiNQF was relevant since VR Fast Track partner companies and job seekers operate in Finland.

3.1.1 European Qualifications Framework

The aim of the EQF is to make different national qualifications in the EU area more understandable and transferrable between countries. Work mobility in the EU region can be promoted when people do not have to revalidate their learning when moving to another country. (European Centre for the Development of Vocational Training (Cedefop) 2014)

The EQF applies to all types of education (basic education, academic, vocational) and it also promotes lifelong learning by validating non-formal learning and informal learning. Non-formal learning refers to learning related to planned activities, but not leading to certification. Informal learning refers to learning occurring as part of daily activities. (European Centre for the Development of Vocational Training (Cedefop) 2014)

The EQF levels and competences are presented in Table 2. The levels are linked with the different educational levels of each country. Finland’s educational levels will be presented in the next section. To get an initial understanding of how the EQF levels connect with the educational system: level 2 equals Finnish lower secondary school, level 6 bachelor’s degree, and level 7 master’s degree.

Table 2: The levels, knowledge, skills, and other competences measured with the EQF (European Centre for the Development of Vocational Training (Cedefop) 2014).

	Knowledge	**Skills**	**Responsibility and autonomy**
	In the context of EQF, knowledge is described as theoretical and/or factual.	**In the context of EQF, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments).**	**In the context of the EQF responsibility and autonomy is described as the ability of the learner to apply knowledge and skills autonomously and with responsibility**
Level 1 The learning outcomes relevant to Level 1 are	Basic general knowledge	Basic skills required to carry out simple tasks	Work or study under direct supervision in a structured context
Level 2 The learning outcomes relevant to Level 2 are	Basic factual knowledge of a field of work or study	Basic cognitive and practical skills required to use relevant information in order to carry out tasks and to solve routine problems using simple rules and tools	Work or study under supervision with some autonomy
Level 3 The learning outcomes relevant to Level 3 are	Knowledge of facts, principles, processes and general concepts, in a field of work or study	A range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying basic methods, tools, materials and information	Take responsibility for completion of tasks in work or study; adapt own behaviour to circumstances in solving problems
Level 4 The learning outcomes relevant to Level 4 are	Factual and theoretical knowledge in broad contexts within a field of work or study	A range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study	Exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change; supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities
Level 5 The learning outcomes relevant to Level 5 are	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems	Exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others
Level 6 The learning outcomes relevant to Level 6 are	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups

	Knowledge	Skills	Responsibility and autonomy
	In the context of EQF, knowledge is described as theoretical and/or factual.	**In the context of EQF, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments).**	**In the context of the EQF responsibility and autonomy is described as the ability of the learner to apply knowledge and skills autonomously and with responsibility**
Level 7 The learning outcomes relevant to Level 7 are	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research Critical awareness of knowledge issues in a field and at the interface between different fields	Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams
Level 8 The learning outcomes relevant to Level 8 are	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	The most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice	Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research

Having a qualification is not the only way to acquire relevant skills to perform certain jobs. EU published a recommendation in 2012 for member countries to specify the process of validating non-formal and informal learning to allow individuals to demonstrate the learning they have acquired outside formal education. (European Centre for the Development of Vocational Training (Cedefop) 2017) Finland has not provided a specific process for validating non-formal education as its description is voluntary (Nousiainen 2020).

3.1.2 Finnish National Framework for Qualifications

The FiNQF illustrates the different levels of the Finnish education system. The FiNQF is designed to be comparable to the EQF, introduced in the previous section. Figure 5 presents the Finnish education system and the relation of different educational levels to the EQF.

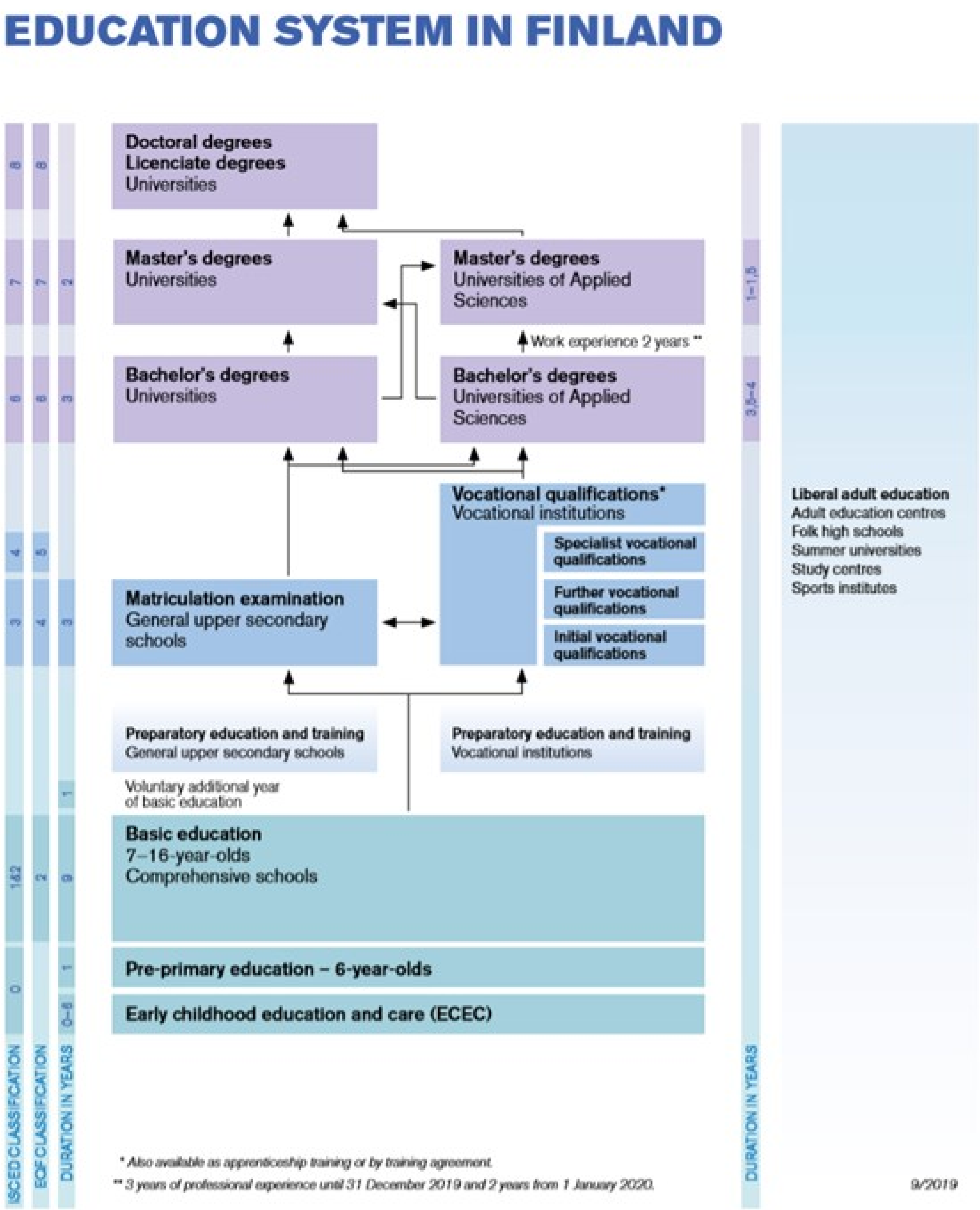

Figure 5: The Finnish Education system (Ministry of Education and Culture 2019).

The Finnish Education system supports flexible study paths. People can move from academically oriented paths to vocational studies and vice versa. Finland provides mandatory basic education for children aged 7 to 16. Basic education takes nine years and represents level 2 in both the FiNQF and the EQF.

The general upper secondary education is non-vocational and leads up to the matriculation examination, measuring students' maturity and knowledge. The matriculation examination is placed on the FiNQF/EQF level 4. Students might also follow a different study path and begin vocational training to prepare themselves for specific work-related skills. Vocational education and its qualifications are determined by national legislation. Finnish vocational qualifications are divided into three competence-based categories: upper secondary vocational qualification, further vocational qualification, and specialist vocational qualification. Based on difficulty, the upper secondary vocational qualification is placed on the FiNQF/EQF level 4, while further and specialist vocational qualifications represent level 5. (Louko, Blomqvist 2018)

The benefit of the FiNQF is that it allows a clear overview of the national education possibilities while providing links to the EQF's overall structure. For the target group of this thesis, the skills normally acquired in vocational training are most relevant due to the skill requirements of the hiring companies. These skills represent the FiNQF levels 4 and 5.

3.2 Bloom's taxonomies

Bloom's taxonomy is the most famous and widely adopted learning taxonomy. In 1956, Dr. Benjamin Bloom initiated a committee to create a taxonomy for classifying educational outcomes. The intention was to offer teachers and trainers a framework for focusing on different types and levels of learning, thus helping to develop learning methods and journeys. The committee defined three domains of learning: cognitive – mental skills, affective – emotions and feelings, and psychomotor – manual or motor skills. (Wikipedia contributors 2020b)

The cognitive domain became the most widely accepted and used model. It classifies learning objectives hierarchically in terms of explicit and implicit cognitive abilities. Figure 6 presents the original Bloom's taxonomy for the cognitive domain. On the first level, a person must be able to store and recall information. By gaining more skills such as comprehending, applying, and analyzing information, a person can move towards the highest levels that represent the ability to synthesize information to form new ideas and evaluate different theories. (Wikipedia contributors 2020b)

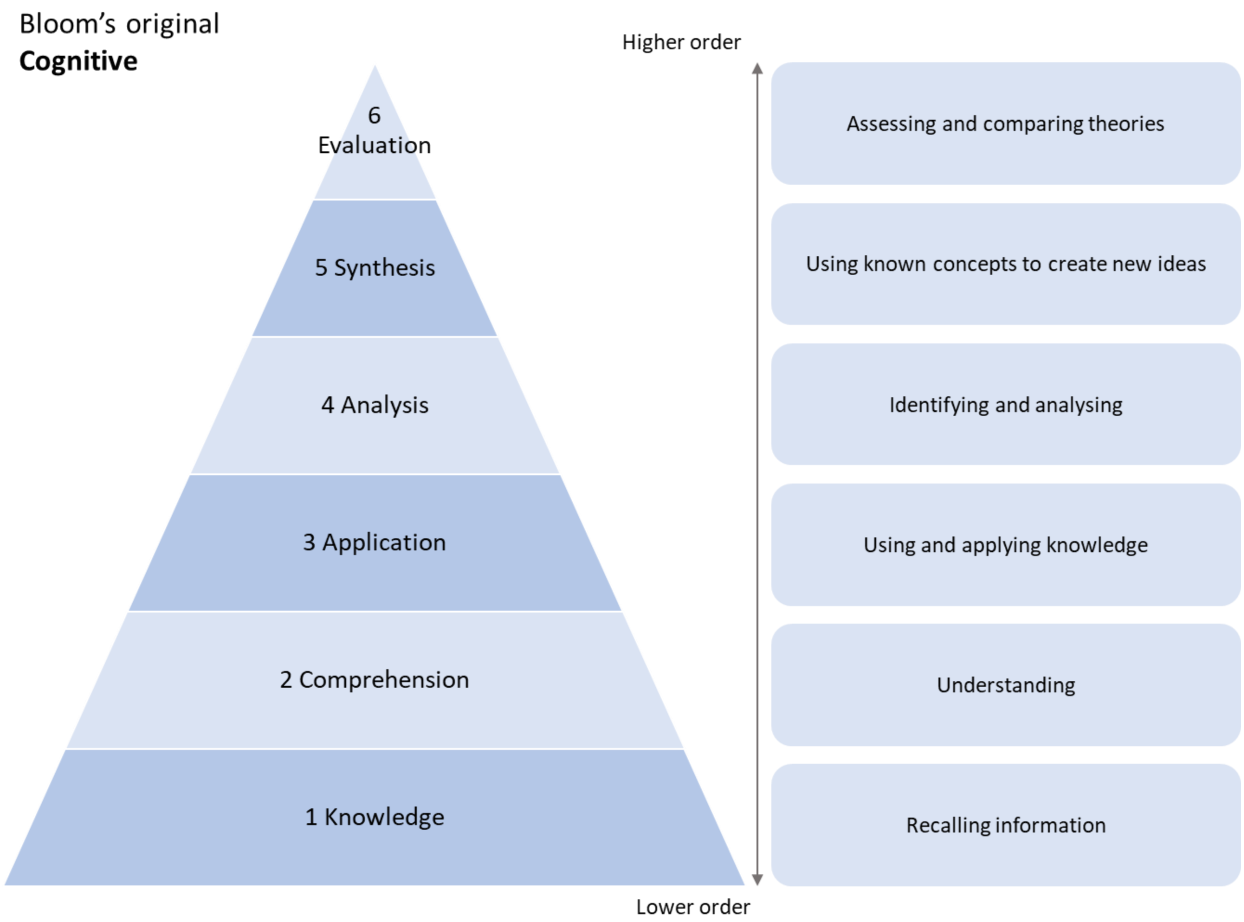

Figure 6. The original Bloom's taxonomy, cognitive domain. Adapted from (Wikipedia contributors 2020b).

3.2.1 Bloom's revised taxonomy: the cognitive domain

In 2001, Lorin Anderson, a former student of Bloom's, and David Krathwohl, one of the creators of the original taxonomy, assembled a group of experts to revise Bloom's taxonomy for the cognitive domain. The reasons to revise had to do with the increased research, knowledge, and new theories on human learning. (Anderson, Kratwohl et al. 2014) The remainder of this thesis utilizes this revised version of Bloom's taxonomy for the cognitive domain.

Like the original Bloom's taxonomy, the revised version contains hierarchical levels. To move from one level to next, the learner must master the preceding level. The main alteration in the revised version was the changing of category titles from nouns to verbs. The purpose was to indicate action, as thinking is an active process; for people to obtain knowledge, they must be actively engaged in the process. Another alteration was the switching of the top two categories. In Bloom's original taxonomy, the highest level of knowledge is evaluation. Anderson et al. viewed that creative thinking is more complex than evaluating. An additional aspect of the revision was to target a broader audience and for the taxonomy to be usable also in adult and advanced training, whereas the original version was best applied to the lower grades. (Anderson, Kratwohl et al. 2014)

Figure 7 depicts Bloom’s revised taxonomy for the cognitive domain. The levels are presented here from the bottom up. On the first level of thinking, a person can *remember*. A person can recognize and retrieve knowledge from memory. The second level of thinking, *understanding*, requires constructing meaning from information. It involves such actions as interpreting, summarizing, classifying, and comparing to be able to demonstrate the understanding by explaining concepts or ideas. The third level, *applying*, involves executing and acting based on the understanding of the knowledge. Fourth, *analyzing* requires a person to break information in parts and define their relations using practices such as attributing or differentializing. For example, defining a skill to be different than knowledge and attributing gaining of knowledge to impact acquiring a skill. The fifth level, *evaluation*, refers to making assessments based on specific criteria or standards. It includes justifying one's decisions and courses of action. The highest level is *creative* thinking, which includes the generation of new ideas, viewpoints, or products. (Anderson, Kratwohl et al. 2014)

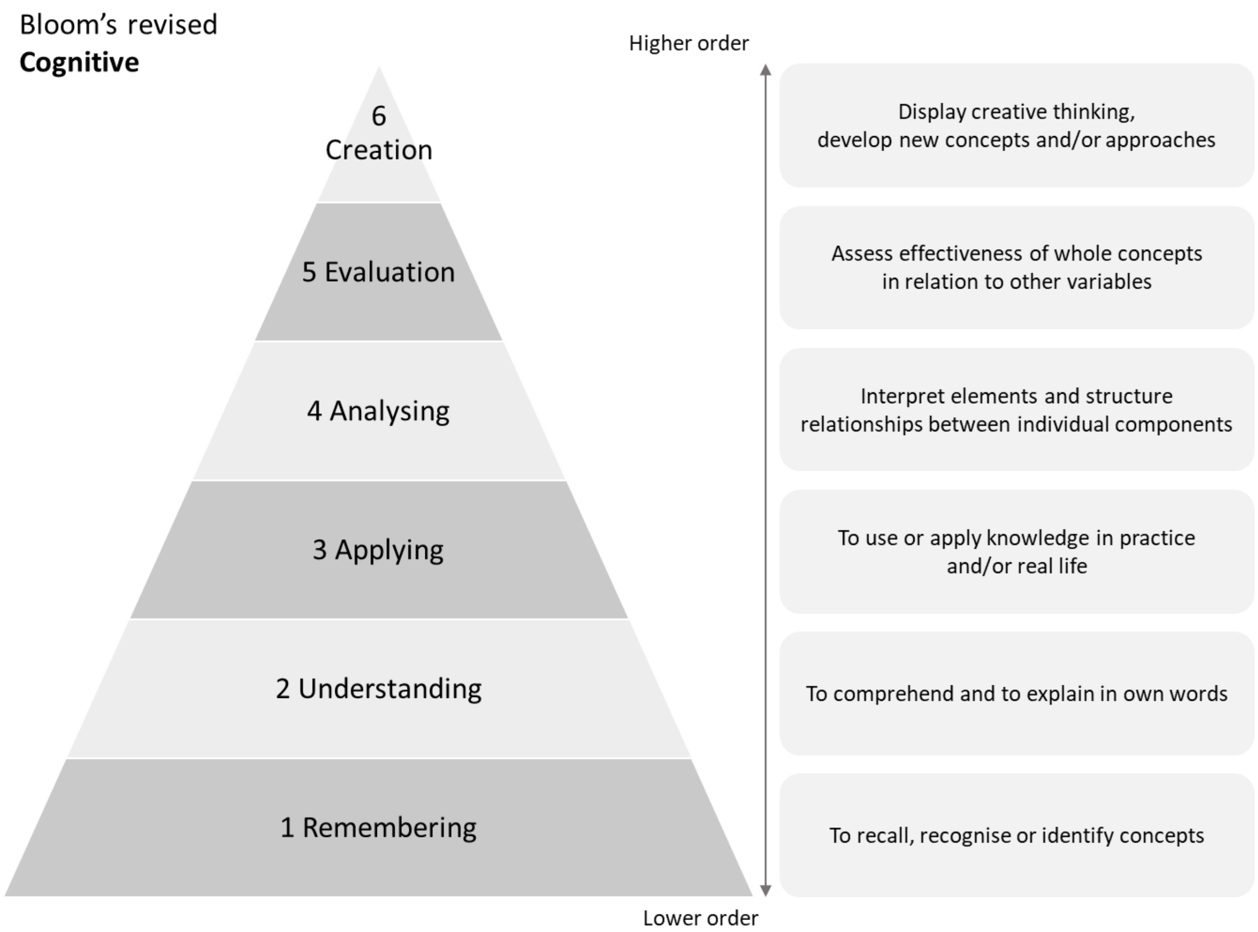

Figure 7. Bloom's revised taxonomy, cognitive domain. Adapted from (Anderson, Krathwohl et al. 2014).

Since the goal of this thesis is to assess the competences people have with the support of tasks performed in a virtual environment, the focus will mostly be on levels 1 to 3, that is remembering, understanding, and applying, respectively. The measurement of task completion on level 1 is that a person can remember appointed matters; on level 2 that a person can explain concepts and/or ideas; and on level 3 that a person can apply this information in their actions.

The benefit of the revised Bloom's taxonomy for the purposes of this thesis is that the structure is clearly hierarchical, making it easier to build corresponding tasks that evolve from recognizing simpler competences towards more complex competences. Bloom's taxonomy is also widely used and accepted, which can make it easier for the stakeholders to understand the goals and purposes of the study.

The revised Bloom's taxonomy is solely focused on cognitive skills. Originally, Bloom's taxonomy spanned three domains, attempting to also cover learning outcomes linked to affective and psychomotor skills. These domains will be shortly introduced in the following sections.

3.2.2 The affective domain

Even though attitudes, feelings, and emotions were defined into their own domain by the original Bloom's committee in 1956, a detailed categorization of the affective domain was only published in 1964 by Krathwohl et al. It consists of a hierarchical model with five levels, as seen in Figure 8. The structure is based on the concept of internalization. It is a process molding a person's identity and sense of self, in which a person moves from general awareness of an attitude or a value to a point where the attitude or value is internalized as a part of the person's identity and it starts to guide the person's behavior. (Krathwohl, Bloom et al. 1964)

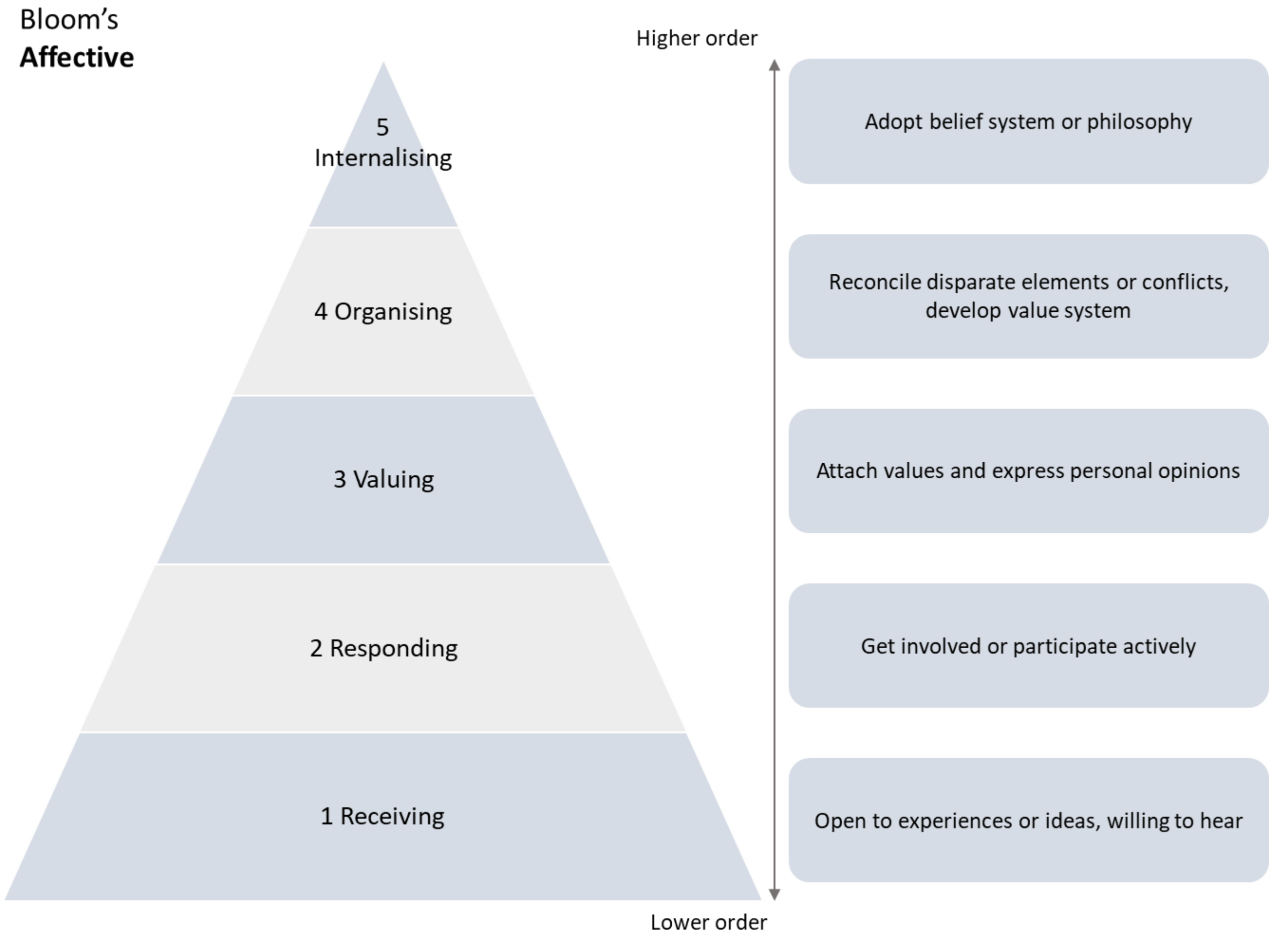

Figure 8. Bloom's taxonomy, affective domain. Adapted from (Krathwohl, Bloom et al. 1964).

The levels in Figure 8 depict different competences related to adapting values. The lowest level, *receiving*, refers to openness towards experiences or ideas. This requires a willingness to listen to others. The second level, *responding*, requires the person to actively participate in the learning process, for example in the form of a conversation. Third, *valuing* is the ability to recognize and express the value of something, for example, proposing plans to improve one's skills. In this example, a person can understand the value of training in improving certain skills. The fourth level, *organizing*, consists of setting up a value system to prioritize certain attitudes over others. A person can analyze and organize values and attitudes in relation to each other. On the highest level is *internalizing*, which means adapting values, attitudes, or feelings on a level where they become automatic and begin to guide a person's behavior. (Krathwohl, Bloom et al. 1964)

3.2.3 The psychomotor domain

Bloom's original committee separated the three domains for learning: cognitive, affective, and psychomotor. A psychomotor component is present in all learning that involves any physical actions. The specific contents of the psychomotor domain were defined only in the 1970s. There are three main versions, created by Dave (1970), Simpson (1972) and Harrow (1972). This study focuses on the taxonomy specified by Dave as it is deemed the simplest and most easily applied version.

Figure 9 illustrates the levels of the psychomotor domain. The initial level, *imitation*, means the ability to observe and copy the actions of others. On the second level, *manipulation*, a person can perform actions based on memory or instructions. *Precision* is accuracy in performing an action without instructions or somebody to imitate. On this level, a person can demonstrate the required actions to a beginner. *Articulation* means being able to coordinate a series of skills and actions. A person can combine their skills to create more complex adaptations. The peak, *naturalization*, is a level where physical actions are automated to a degree where they occur naturally, without conscious effort. (Dave 1970)

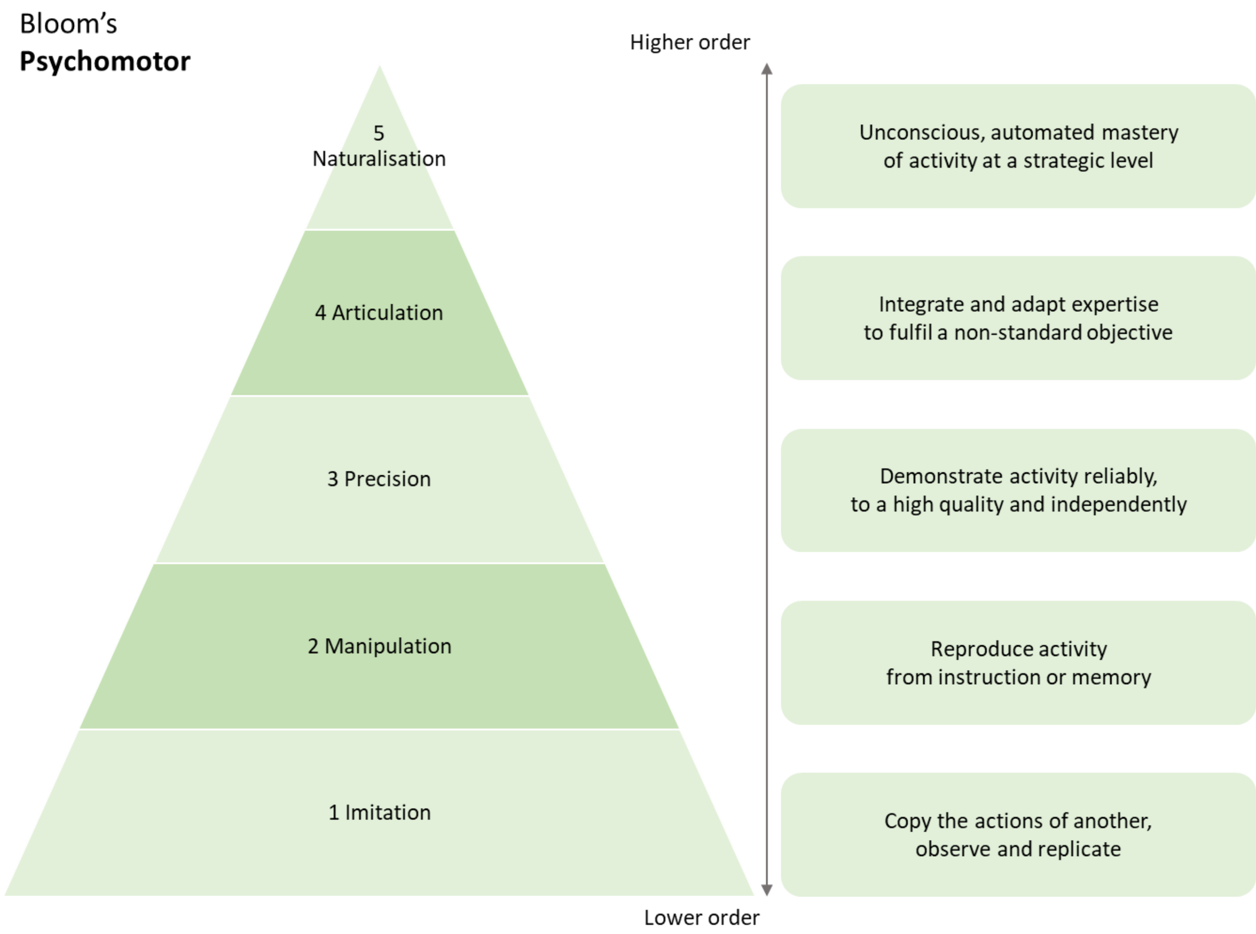

Figure 9: Bloom's taxonomy, psychomotor domain. Adapted from (Dave 1970).

3.3 Marzano's New Taxonomy

Robert Marzano created what he called the New Taxonomy of Educational Objectives. It was intended to provide an enhanced, more research-based alternative to Bloom's cognitive taxonomy. Marzano's focus was also on cognitive abilities, specifically on how best to teach students to think. This model was designed as a tool for practitioners, not as an explanatory theory on how the mind works. (Marzano, Kendall 2007)

Marzano's New Taxonomy, illustrated in Figure 10, consists of three main systems: the *self-system*, the *metacognitive system*, and the *cognitive system*. The self-system identifies a person's beliefs, behaviors, and motivation. The metacognitive system sets and tracks goals. The cognitive system processes information and consists of four subcomponents: retrieval, comprehension, analysis, and knowledge utilization. Surrounding these three main systems are three *domains of knowledge:* information, mental procedures, and psychomotor procedures. Knowledge refers here to storing and retrieving information. (Marzano, Kendall 2007)

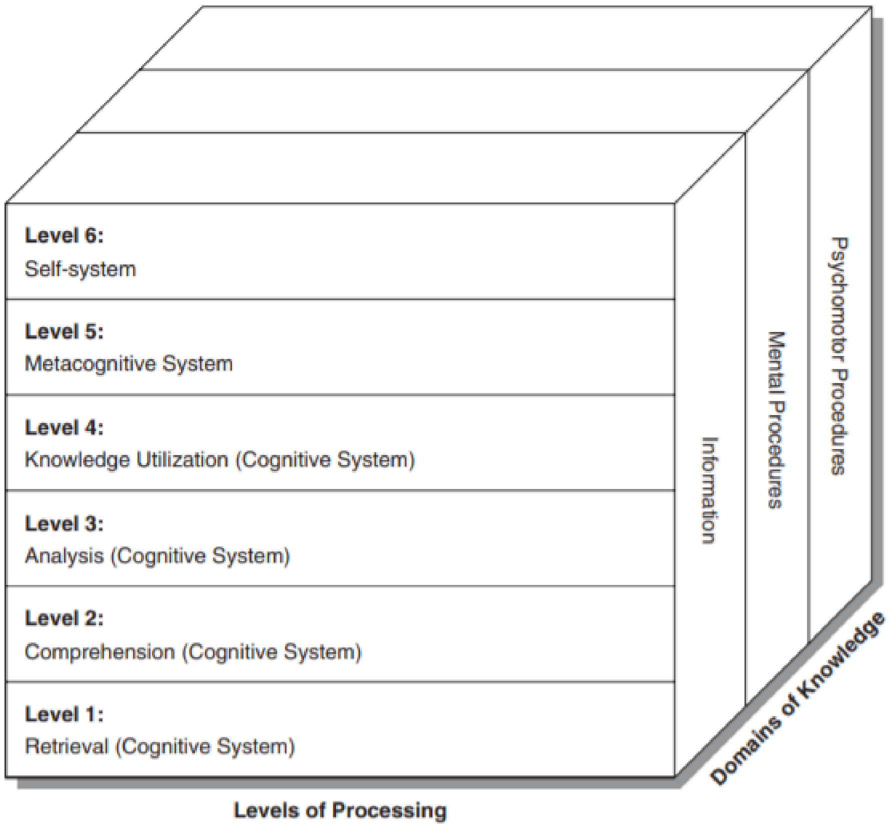

Figure 10: Marzano's New Taxonomy (Marzano, Kendall 2007).

Marzano's New Taxonomy is a two-dimensional model with six categories of mental processes represented by one dimension and three domains of knowledge represented by the other dimension. The main purpose of the taxonomy was to classify educational objectives. It also serves as a framework for designing learning assessments, since different types of objectives require different types of assessments.

3.4 Significant Learning and Six Facets of Understanding

Significant Learning and Six Facets of Understanding have both emerged from the need to broaden the understanding of what competences and skills are relevant for learning. Both models are non-hierarchical, and they complement the previously presented taxonomies by highlighting aspects of learning that are difficult to measure yet present in all human activities, such as self-awareness and empathy. Since such “softer” competences linked with human interaction are especially relevant in this thesis’ target industry, including taxonomies that emphasize them was relevant.

3.4.1 Significant Learning

Dr. L. Dee Fink created the Significant Learning taxonomy to illustrate the different abilities people need to develop to learn in a profound way. Bloom’s taxonomy was widely used by teachers, but Fink argued that especially the learning outcomes of higher education were not easily derived from it. Bloom’s taxonomy was also thought to be too narrow to cover different types of learning such as learning how to learn, how to adapt to change, and interpersonal and communication skills. Significant Learning views learning as change. If nothing changes, nothing was learned. The change should be lasting and important in the learners’ life – significant change. (Fink 2003)

The six learning dimensions of the Significant Learning taxonomy are shown in Figure 11. The dimensions are not hierarchical but are all equally important and interactive facets of learning. *Foundational knowledge* means the basic understanding that enables all learning. Knowing is seen as a person’s capability to understand and remember information and ideas. *Application* refers to learning resulting from engaging in new activities. Its main value is that it enables learning to become useful. Application covers physical and social activities as well as intellectual ones. *Integration* happens when a learner connects information, and its main usage is regarding power. The learner gains more power as they connect information in a meaningful way. (Fink 2003)

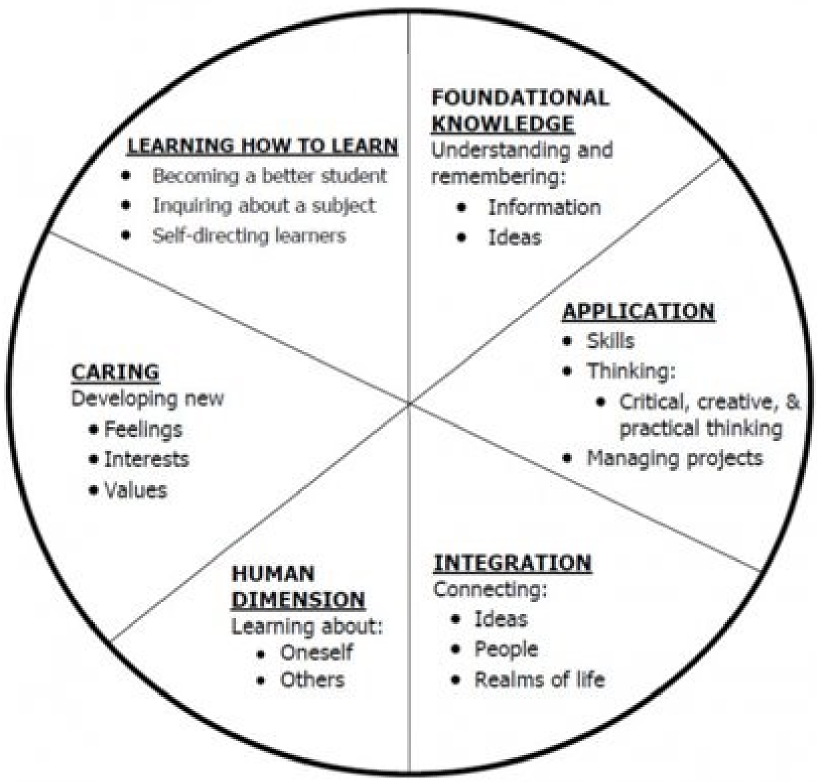

Figure 11. The dimensions of Significant Learning (Fink 2003).

The *human dimension* means learning something new about yourself or others. It involves gaining a better understanding of why people act and learn the way they do. It also involves a person's understanding of themselves. *Caring* refers to a change in feelings, values, and/or interests as a result of learning. A learner might, for example, find themselves caring more about a certain topic. The benefit of this is to ensure energy; when a person cares about something, they are more enthusiastic about it and have more energy for additional learning. Finally, *learning how to learn* concerns the learning process itself. When a person understands how they learn, the effectiveness of learning increases. (Fink 2003)

3.4.2 Six Facets of Understanding

Six Facets of Understanding was defined by Wiggins and McTighe in their 2005 book, Understanding by Design. The taxonomy was aimed at teachers to better understand and improve teaching processes and methods. The fundamental idea is that for learning to take place, all the six facets of understanding need to be developed and matured. (Wiggins, McTighe 2005)

The six facets are illustrated in Figure 12. The ability to *explain* means the learner can understand the how, what, why, and where related to a specific matter and is able to demonstrate and describe their understanding. *Interpretation* refers to making sense of things and being able to create meaning and metaphors. Interpretation allows a person to make predictions and hypotheses based on their understanding. *Application* means using and adapting knowledge. By applying knowledge, a person can, for example, solve problems or creatively adapt to new situations. By having *perspective,* the ability to think critically and view things from multiple sides emerges. A person can analyze contrasting view-points and produce collective conclusions. *Empathy* is the ability to appreciate people who think differently. With empathy, a person can describe other people's emotions and ana-lyze their reactions. Lastly, *self-knowledge* is the learner's ability to assess their own learning habits, strengths, and weaknesses. (Wiggins, McTighe 2005)

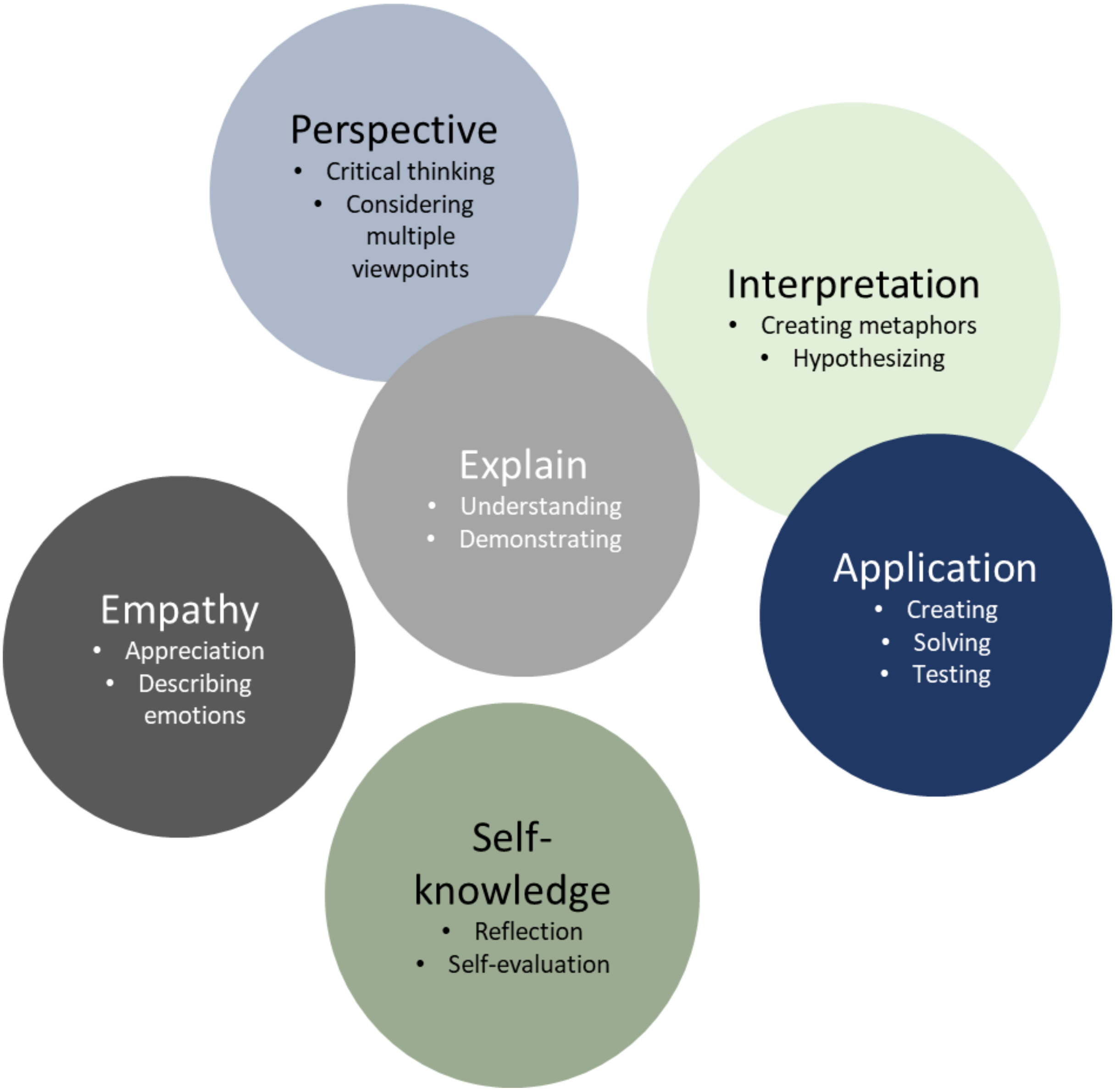

Figure 12. The Six Facets of Understanding. Adapted from (Wiggins, McTighe 2005).

Like Significant Learning, Six Facets of Understanding is a non-hierarchical taxonomy. All the facets are equally important and support each other (Wiggins, McTighe 2005).

Nevertheless, one can rationalize that certain facets must be mastered before others can occur. For example, before a person can apply knowledge, they must have at least a basic understanding of it. Then again, self-knowledge and empathy can be seen as over-arching competences that are valuable in all learning and human interaction.

4 VR Fast Track competence recognition framework

Based on the consideration of the existing learning taxonomies, it became evident that they did not fully meet the needs of the VR Fast Track project. A new synthesis framework was therefore developed to enable competence recognition in such use cases as the project required. Justification for this decision is given below.

None of the existing learning taxonomies specifically focus on competence recognition from the point of view of an employer – what is required to execute a particular job. This is the employers' main point of interest; academic classifications of the applicant's knowledge and skill base are often less important. Again, this is especially true for the target industry and roles of this study. Focusing competence evaluation on concrete work performance was a key driver for this framework proposal.

The thesis attempts to support the recruitment process, which is typically fast paced and not conducted by pedagogy experts. This means that clear, concrete, job role-driven competence recognition guidelines are needed. Moreover, employers' needs vary significantly, also within job roles, meaning that requirements for applicants are not necessarily linear across all competence dimensions. An employer might require strong competences in one dimension and less in another. These requirements might also vary according to each individual open position. The existing taxonomies are not very usable for these kinds of variable needs. A lightweight, easily understandable, and adaptable framework was thus needed, but with enough detail to provide a concrete backbone for the recruitment process.

Pair and team work skills are not highly emphasized in any of the existing taxonomies, although Significant Learning and Six Facets of Understanding do incorporate such viewpoints. These skills are vitally important in most current professions, but especially so in the target industry and roles of this study, as such work is often organized in a pair or team mode. It was therefore necessary to include them as their own competence dimension. This also helps to highlight their importance during the recruitment process.

The EQF is quite close to what was needed, but in addition to the abovementioned shortcomings, it was not considered comprehensive enough on representing affective competences, which are especially important in the study's focus area. As to Bloom's, the focus of each separate domain model is too narrow for this study's needs, and a ready-made combination of the domains is not available. Marzano's New Taxonomy is too heavily focused on cognitive abilities, and concrete applications of this somewhat complex model are hard to locate.

Significant Learning is too focused on the learning process to be used directly for the recognition of existing competences. Moreover, Significant Learning and Six Facets of Understanding are too sweeping to be used as a framework for providing comparable results in assessing people's competences. These two taxonomies are better suited to providing the philosophical background for understanding learning, and that is how they have been used in developing this framework proposal.

To provide support and flexibility to employers' recruitment processes and to be able to eventually create a "curriculum" of competence recognition VR tasks, it was decided that a hierarchical framework would be built. This way a user can either begin with lower-level tasks and progress to higher levels, or only higher-level tasks can be executed, since they will cover the competences of the lower levels. The idea was to make it easier for employers to adapt the framework to different job roles and applicants – a particular applicant might require more tasks to demonstrate their skills than another, and filling in a more complex position would likely benefit from evaluating performance in a wider range of tasks.

The following section describes the process of synthesizing the existing learning taxonomies to provide a starting point for building the framework proposal. Next, the general competence recognition framework is presented, followed by an example of how it was applied to the care industry.

4.1 Synthesis of existing learning taxonomies

In Figure 13, the studied taxonomies are mapped together to provide an understanding of their similarities. The hierarchical taxonomies (the EQF, Bloom's revised cognitive domain, and Marzano's cognitive system) are organized according to their difficulty level. Due to our target group and the target job roles, the focus is on competence levels 1 to 4. With the EQF, the focus in this mapping was on skills connected to practical work, it being central to the target job roles. The FiNQF was left out of the comparison as it only focuses on Finnish educational levels.

Level	EQF skills	Bloom's revised cognitive domain	Marzano cognitive system	Significant Learning	Six Facets
1	Basic skills required to carry out simple tasks	Remembering - To recall, recognise or identify concepts	Retrieval	Foundational knowledge - Understanding and remembering	Explanation
2	Basic cognitive and practical skills required to use relevant information in order to carry out tasks and to solve routine problems using simple rules and tools	Understanding - To comprehend and explain in own words	Comprehension	Foundational knowledge - Understanding and remembering	Inter-pretation
3	A range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying basic methods, tools, materials and information	Applying - To use or apply knowledge in practice and/or real life	Analysis	Application - Skills, thinking	Application
4	A range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study	Analysing - Interpret elements and structure relationships between individual components	Knowledge utilization	Integration - Connecting ideas	Perspective

Figure 13. Mapping of the selected taxonomies. Levels 1 to 4 for hierarchical taxonomies and the closest estimation for the non-hierarchical taxonomies.

For the non-hierarchical taxonomies, Significant Learning and Six Facets of Understanding, a competence dimension best suited to each level was selected. The selection was based on the authors' understanding of the taxonomies and the competences. Non-hierarchical taxonomies do not provide exact matches as their dimensions are broader and overlap noticeably more compared to the hierarchical ones. All in all, as the topic is highly complex, this mapping is altogether heuristic in nature.

The EQF level 1 focuses on basic skills for simple tasks. In Bloom's, the first level is remembering concepts. This interpretation is also shared with Significant Learning. In Marzano's New Taxonomy, retrieval represents the first level. In Six Facets of Understanding, explanation can be seen as the foundational facet.

The second level of the EQF requires basic cognitive skills to use information to carry out tasks and solve routine problems. Bloom's sees the second level as understanding and being able to explain in one's own words. In Marzano's New Taxonomy, comprehension fits this level. Interpreting in Six Facets of Understanding refers to creating your own story based on your understanding. The mapping of Significant Learning remains as it was on the first level.

The third level concerns the application of knowledge. For the EQF, this is phrased as the skills to apply knowledge to accomplish tasks and solve basic, but not routine, problems. Bloom's provides a clear match for the application of knowledge, as do Significant Learning and Six Facets of Understanding. Marzano's analysis is linked to this level.

The fourth level of the EQF consists of the skills required to generate small-scale solutions to specific problems. In Bloom's, the fourth level is analyzing and creating connections. Significant Learning has a similar, integrative approach that results in forging new connections. Knowledge utilization from Marzano can also be interpreted as a comparable activity. With Six Facets of Understanding, perspective brings the idea of considering multiple viewpoints.

Condensing the common denominators of the selected taxonomies, a model shown in Figure 14 was created. It merges the cognitive and psychomotor competence dimensions of the foundational taxonomies. The synthesis shows a progression from using existing knowledge for executing simple tasks, to being able to solve routine and basic problems, and finally the ability to create new solutions to limited problems. This progression largely follows that of the EQF levels 1 to 4, which formed the focus area of this thesis. The presentation in Figure 14 is a simplification of the complex taxonomies, and its main value is in outlining a hierarchy of the competence levels. This hierarchy was used as the starting point for building this thesis' competence recognition framework proposal.

Level	Common denominators
1	Remembering and reproducing foundational information and using it to execute simple tasks.
2	Understanding, selecting, and interpreting information and using it to solve routine problems.
3	Applying information and skills and using them to solve basic problems.
4	Analysing and integrating information and skills and using them to generate solutions to specific problems.

Figure 14. A synthesis of the selected foundational taxonomies.

4.2 General competence recognition framework

The general competence recognition framework attempts to provide an industry-independent view of competences required to perform vocational work, defined in this study as the EQF levels 1 to 4. However, the framework was composed in such a way that it could be expanded later. The framework is presented in Appendix 3 due to its mode of presentation, but it is described in this section.

The framework is composed of four numbered levels plus self-awareness skills, which will be discussed later. The numbered levels are further divided into competence requirements in four dimensions: cognitive (thinking) skills; psychomotor (physical) skills;

affective (emotional) skills; and pair and team work skills. These dimensions were selected to represent the major competence areas in modern working life. Using dimensions also allows a more detailed observation of the different competence requirements. It also makes it possible to mix and match competence levels, as certain job roles might require, for example, level 3 cognitive skills but level 1 psychomotor skills.

On level one of the framework, competence requirements are based on basic general knowledge and skills that a person could have without much formal education or any field-specific knowledge. On this level affective skill requirements entail the ability to interact in simple scenarios, and pair and team work skills include supervised work based on instructions or imitation. These competences make it possible to execute simple assisting tasks.

On the second level, basic field-specific knowledge and skills are required to be able to execute simple vocational tasks. Affective competences become more complex, including making and responding to queries and thus keeping the conversation flowing. On this level a person can already work partially independently and base their actions on memory.

The third level focuses on standard vocational tasks. Executing them requires advanced field-specific knowledge and skills. On this level a person should be able to engage in constructive argumentation and work both with a team and independently, being accountable for the completion of his/her own tasks.

The fourth level involves the execution of non-standard tasks, meaning that a person must be able analyze and interpret existing information and based on this deliberation, select, or create solutions to specific problems. The same requirement for adaptation also goes for psychomotor skills and tool use. Affective requirements include the ability to manage moderately difficult interaction situations. On this level a person can already oversee others' simple tasks and take part in work process improvement.

Self-awareness skills provide a backdrop to all other skills – without them competences in the other dimensions cannot flourish. This decision was supported by partner company representatives reviewing the framework. Moreover, measuring self-awareness skills was deemed to require such advanced knowledge that it was left out of project scope. Self-awareness skills are therefore placed outside the hierarchical structure, but it was still considered important to include them in the model. Self-awareness serves as a prerequisite for fruitful collaboration as well as understanding your skill levels and identifying when you need more education or practice.

4.3 Application to the care industry

One of this study's objectives was to define care industry-specific competences for target roles and incorporate them to the composed general competence recognition framework. An understanding of such field-specific competence examples was needed for the creation of useful, concrete VR tasks.

The initial plan was that VR Fast Track partner companies would be highly engaged in the development and approval process of the care industry-specific competences. This would have been ideal and in accordance with the service design approach, since hiring employers determine the job roles and responsibilities, and thereby the required competences. However, as has been discussed in Section 2, the coronavirus pandemic inundated the partner companies with extra work and made such collaboration much scarcer than initially planned.

The care industry-specific application of the competence recognition framework has been iterated and reviewed with partner company representatives but is nevertheless primarily a draft that illustrates how the general framework could be applied to particular fields. The framework is presented in Appendix 4 due to its mode of presentation, but it is described here.

The righthand column of the framework includes examples of concrete competences that could be relevant on each competence level (1 to 4). These examples originate from the interviewed partner company representatives, and therefore reflect the job roles this specific company has. It is noteworthy that for this reason all the current examples may not be directly compatible with the industry-independent competence requirements of the framework. Any possible discrepancies should be reconciled in future iterations.

Each level can include several competence requirements along the four different dimensions, namely cognitive, affective, psychomotor, and pair and team work. This is natural since employers typically have numerous requirements. Conversely, not all levels or dimensions must have requirements but can also be left blank. In the example in Appendix 4, level 1 includes two cognitive competences, COG 1.1 and COG 1.2, where the first numeral relates the level and the second the running number of the competence within each dimension. These can then be linked to VR competence recognition use cases, creating an audit trail between employers' requirements and the technical design. A VR use case can link to several competences from different dimensions and/or levels, or only focus on one competence – this depends wholly on the competence scenario being examined.

The overarching idea of the current examples is that each dimension has a competence that exists on different levels, making it easier to assess the job seeker's level in the VR tasks. For example, cognitive language skills range from the very basics to fluency in everyday situations. Likewise, in psychomotor skills, the first level entails simple assisting tasks, while the fourth level contains the independent mastering of more complex procedures.

Self-awareness skills remain the same in this applied version of the competence recognition framework. This is because they are thought to be so general as to be relevant in most fields. Their appraisal in the VR use cases could happen by including specific tasks for the user, for instance to explain and justify decisions or assess their performance during or after task execution.

The framework was built to accommodate flexible needs. Its idea is also to build a competence library of sorts that employers can use to hone their recruitment processes and find applicants that better fit their changing needs. Building more useful and advanced competence recognition use cases becomes possible as VR technology develops. The next section looks at the basics of VR to understand what needs to be considered in building the use cases.

5 Virtual reality

This chapter gives an overview of VR, starting with putting VR into perspective with other forms of reality. Next, VR system components are introduced on a basic level, after which the user experience of virtual environments is considered. A discussion on the relevance of VR concerning learning and competence recognition follows, after which the current challenges and future possibilities of VR are briefly outlined.

5.1 Forms of reality

Typically for rapidly developing fields, even the basic concepts surrounding VR are as yet partially unstable. This also applies to how realities are conceptualized and where virtual reality fits in. Figure 15 shows a common classification for the main forms of reality along a virtuality continuum. The continuum is discussed in this section based on Jerald (2016, pp. 29-30).

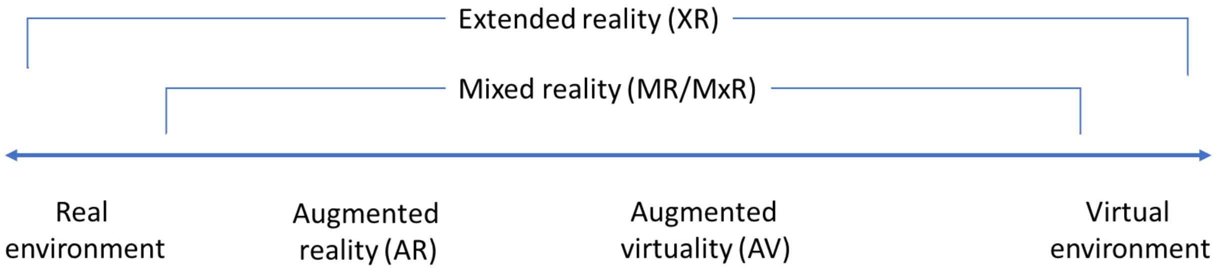

Figure 15. The virtuality continuum. Adapted from (Milgram, Kishino 1994).

Extended reality (XR) is the top-level concept that covers the whole spectrum from wholly real environments to wholly virtual environments in all their current and future forms. *Mixed reality* (MR, sometimes MxR) is the next level, representing the merging of real and virtual realities, but neither in their pure form.

The real environment is the real, physical world we inhabit. Other forms of reality sometimes attempt to replicate or simulate it, but not necessarily: it depends on the goals of the VR application.

Augmented reality (AR) does not attempt to replace reality but adds stimuli to it, often with the goal that a user cannot distinguish between stimuli of computer-generated origins and the real environment. In short, virtual elements complement the real world. A well-known AR example is the smartphone game Pokémon Go.

Augmented virtuality (AV) merges content such as physical elements, images or film captured from the real environment and brings them to virtual realities. Real-world elements therefore augment the virtuality. Immersive 360° films are examples of AV.

Finally, pure virtual realities are wholly computer-generated and do not utilize any real-world elements. They may replicate the real environment to some degree or not at all. The goal is to fully engage the user in another, *virtual environment* (VE) so that the real world it temporarily forgotten. This requires some level of interaction between the user and the VR system. VEs are typically created using game engines, the top rated of which are currently Unity 3D and Unreal Engine (G2 2020).

This thesis focuses on VR as implemented and experienced via AVs and VEs. If other forms of reality are discussed, this is explicitly mentioned. For the purposes of this study, VR can therefore be defined as “an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment” (Merriam-Webster 2020).

5.2 VR systems

This section gives an overview of VR system components with the intention of forming an understanding of how the user and the VR system interact. This interaction, as well as the multisensory VR experience altogether, is enabled by input and output devices, which are introduced shortly.

5.2.1 Overview

VR systems strive to engage users so comprehensively that they experience the artificial environment as real. This requires intuitive, seamless interaction between users and the VR system; human-technology interaction but also human-to-human interaction within the VR experience, all enabled by dedicated hardware and software. Figure 16 gives an overview of this system, which exists as a continuous input-output loop during the length of a VR experience.

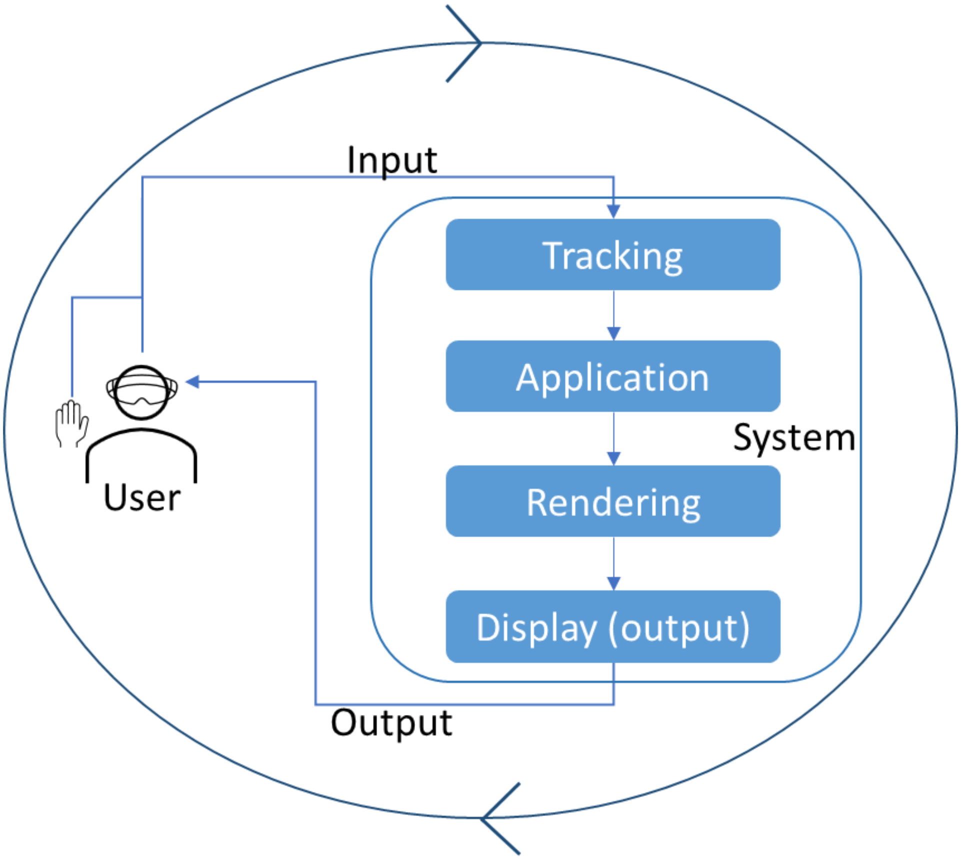

Figure 16. Overview of a VR system and its data flow to and from the user. Adapted from (Jerald 2016, p. 31).

Figure 16 is explained here based on (Jerald 2016, pp. 30-32). *Input* is data from the user: head and hand tracking information, controller button presses and so on. This human input is tracked by the VR system and translated to machine-understandable, digital format. The VR application, in charge of the non-rendering aspects of the VE, receives this input and updates the environment accordingly. These updates concern, for instance, user interaction and geometry and physics simulations. Rendering transforms the digital information to a human-understandable format, be it related to visual or auditory experiences or the sense of touch. Drawing a geometrical object is an example of rendering. Finally, *output* is the physical manifestation produced by the VR system and experienced by the user, such as seeing the geometrical object as pixels on a display, or hearing sound waves in headphones.

The seamlessness of this human-technology interaction is vital for agreeable VR experiences, and it is much dependent on selecting appropriate input and output devices for each use case. The most common of these are presented shortly below.

5.2.2 VR devices

VR devices are sometimes separated into input and output devices following the data flow division presented in Figure 16. This division is somewhat artificial since many devices act in both roles, for example hand-held controllers. Regardless, this input/output division is used here to provide structure.

Output devices

Speakers, visual displays, and haptics are typical VR output devices. Instead of static speakers, headphones are often used, as they help block out the real environment. Ambisonics, a format for full-sphere surround sound, is an increasingly preferred way for providing spatialized audio in VR (Wikipedia contributors 2020a), helping to create a more engaging experience.

There are three main types of visual displays (Jerald 2016, pp. 32-34). First, head-mounted displays (HMD), which are worn either by themselves or as part of, for example, a helmet. HMDs may be standalone, meaning all the technology required for the VR experience is integrated into the HMD, or tethered to another device (such as a PC or a video game console), whereby the HMD only acts as a display. The second main type is world-fixed displays, where content is rendered on stationary surfaces that do not move with the user. These range from common flat monitors to cubelike CAVEs that surround the user. The third main type is hand-held displays, which are typically simple VR viewer structures attached to a smartphone or a tablet. Figures 17, 18 and 19 display examples of a hand-held display, a CAVE, and an HMD, respectively. Clearly, the level of technical and experiental sophistication offered by these solutions vary noticeably, as do the options for other sensory elements that can be used.

Figure 17. Google Cardboard hand-help display. Image courtesy of (Google 2020).

Figure 18. VR CAVE. Image courtesy of (Antycip Simulation 2020).

Figure 19. Oculus Quest HMD and hand-held controllers. Image courtesy of (Oculus 2020a).

Besides auditory and visual, human interaction is largely bodily. Haptics incorporate the sense of touch to VR by creating artificial forces between the user's body and the virtual objects (Jerald 2016, pp. 36-39). A classification of haptics is presented in Table 3. This classification provides numerous combinations for VR implementations. For instance, common hand-held VR controllers, seen in Figure 19, are an example of active, proprioceptive, self-grounded haptics. A real-world piece of equipment that the user can first touch and whose shape is then matched to a virtual double is an example of passive haptics, which are a relatively resource-efficient way to increase sense of realism in VR. Active haptics are more complex to implement but permit greater flexibility.

Table 3. Classification of haptics. Adapted from (Jerald 2016, pp. 36-39).

<table>
<tr><td rowspan="3">Passive
Static physical objects available for touching in the real world and mapped to a virtual object.</td><td colspan="2">Active
Computer-controlled devices that provide physical feedback to the user via electronic, electric, or mechanical channels; no real-world link.</td></tr>
<tr><td>Tactile
Provides sense of touch through the skin.</td><td>Proprioceptive
Provides sense of touch through joints or muscles.</td></tr>
<tr><td>Self-grounded
Worn or held by the user.</td><td>World-grounded
Linked to a static object in the real world.</td></tr>
</table>

While methods of auditory and visual output in VR are already somewhat realistic, haptic experiences are still rare, fall far below users' expectations in quality, and are extremely limited compared to real-world haptic possibilities (Wang, Guo et al. 2019). Currently the most advanced example of commercially available haptics are hand-held controllers that vibrate or rumble; generalized haptics are non-existent. As Wang et al. state, "there is an urgent requirement to improve the realism of haptic feedback for VR systems, and thus to achieve equivalent sensation comparable to the interaction in a physical world".

Less commonly used VR output devices pertain to other human senses. These solutions are even less commonly available than haptics, so they are mentioned only briefly. VR users' physical movement and sense of gravity are enabled by motion platforms and treadmills. These can help synchronize motion seen in VR and felt in the real world, potentially deepening user engagement and reducing motion sickness (Jerald 2016, pp. 39-42). The car seat in Figure 18 could act as a motion platform. Motion platforms and treadmills can also produce input to the VR system. Finally, R&D is underway to include other sensory modalities to VR, including the senses of smell and taste and the perception of temperature and wind.

Input devices

Let us then consider input devices. Currently, hands are arguably the most important method for interacting in VR. Hand input devices can be world-grounded (e.g. gamepads, joysticks, or the steering wheel in Figure 18), hand-held (e.g. common controllers such as in Figure 19), or hand-worn (e.g. glove controllers) (Jerald 2016, pp. 311-317). Hand input devices can be tracked by the VR system (e.g. gloves) or not (e.g. gamepads). The tracking of bare hand has also recently become commercially available, albeit in very restricted use cases (Peters 2020). If the usability and use range of this feature improves, it could be a significant step towards more intuitive interaction in VR.

Non-hand input devices include head, eye, and full-body tracking, as well as microphones (Jerald 2016, pp. 317-321). Of these, microphones are used to enable voice-activated interaction in cases where speech recognition is implemented in the VR system. Full-body tracking is a powerful tool for increasing users' sense of self-embodiment and interaction realism. It can also markedly aid human-to-human interaction within the VR environment. Eye tracking observes where the eyes are looking, and this input can be used for instance for pointing at or selecting objects in VR. Its proper implementation can be tricky, since people use their gaze in versatile ways, not all of which are meaningful. Nevertheless, it is useful particularly in facilitating more subtle VR character interaction. This is also true for head tracking, which provides similar possibilities, added with simple head gestures, such as nodding and shaking.

Other observational and measurement devices may also be used to deepen interaction in VR. These include recording heart rate (or its variability), skin conductivity, electroencephalogram (EEG), and functional magnetic resonance imaging (fMRI). These devices are currently not available for commercial VR use.

5.3 Experiencing virtual environments

After reviewing the basic interaction channels and devices used in VR systems, this section considers how humans experience AVs and VEs. Optimally, VR provides an altogether different experience from other forms of media, encompassing the user in another reality. Various factors affect users' VR experience, the most important of which are summarized in Figure 20 and covered in more detail in the following subsections.

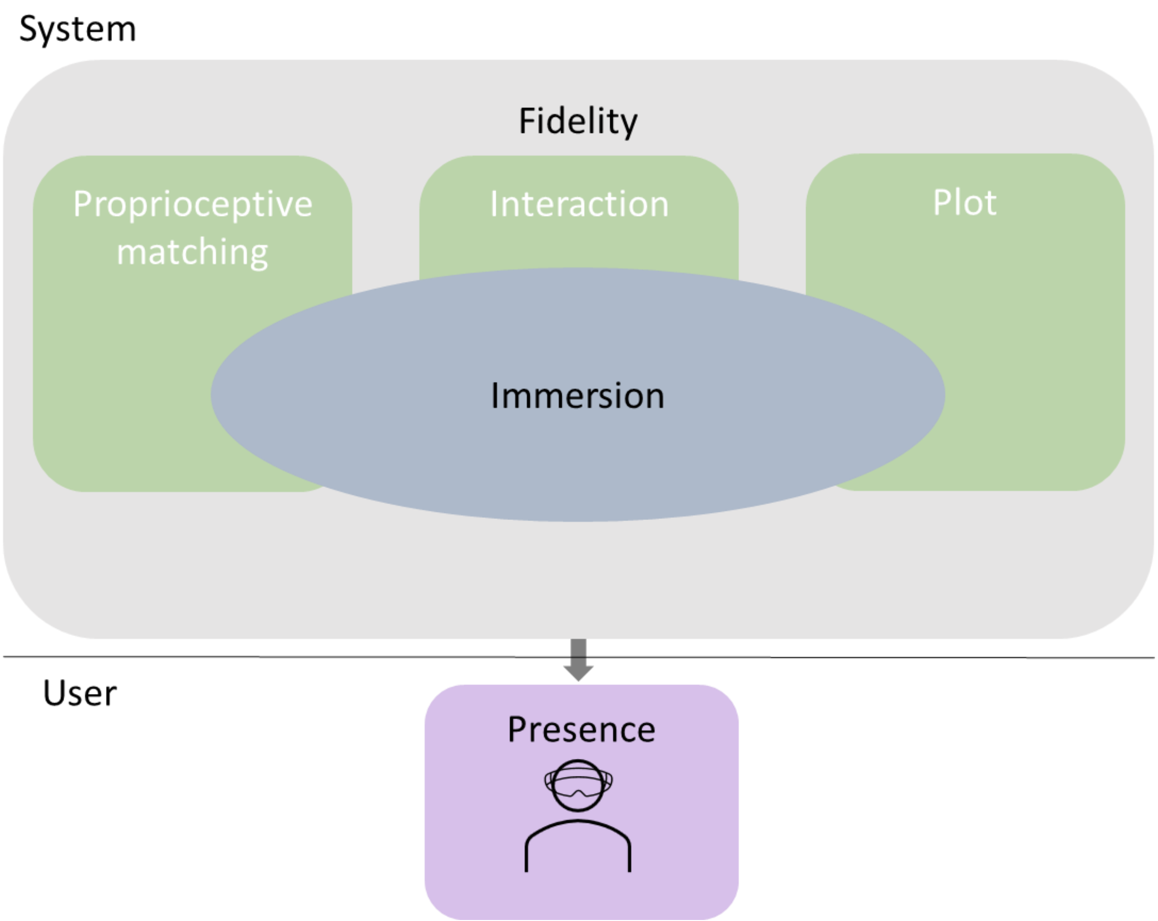

Figure 20. Immersion, fidelity, and presence are some of the key concepts affecting VR user experience. Immersion and fidelity are system properties, presence is each user's subjective state. Proprioceptive matching, interaction, and plot are prerequisites for immersion.

5.3.1 Immersion

VR systems attempt to immerse the user in a computer-generated environment. *Immersion*, shown in blue in Figure 20, "describes the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant" (Slater, Wilbur 1997, p. 3). *Inclusiveness* relates to the degree to which the real environment is blocked out by the visual display(s). *Extensiveness* concerns sensory multi-sidedness; how the five human senses of sight, hearing, smell, taste, and touch are taken into account. *Surrounding* deals with how panoramic a VE is, as opposed to a restricted view. *Vividness* relates especially to specific technical aspects such as resolution and display or audio quality. These four aspects specify how immersive a VE is.

To summarize, immersion is a function of the technological characteristics of the VR system, and as such it can be objectively assessed. The more advanced these characteristics of the VR system are, the more immersive it is.

Slater and Wilbur (1997) also discuss three prerequisites for immersion, shown in light green in Figure 20. The first is *proprioceptive matching*, meaning the synchronization of the physical body's movements to what is experienced in VR. This requires self-embodiment through some sort of a *virtual body* (VB), at least in the form of a coherent egocentric viewpoint. The user should be able to control the VB, ideally with *six degrees of freedom* (6DoF). 6DoF refers to the total number of ways a rigid object can move in three-dimensional space: translational (forward/back, up/down, left/right) and rotational movement (yaw, pitch, roll). If a VR system only has, for instance, 3DoF tracking (that is, only rotational movement), as is the case for smartphone-based hand-held displays, it will limit immersion.

The second immersion prerequisite is *the ability to interact*; users must be able to influence the experience with their actions (Slater, Wilbur 1997). Device support for interaction was discussed in the previous section. Third, a distinct, captivating *plot* is required. There must be a proper storyline behind the VR experience to truly immerse the user.

There is currently no commonly agreed system for representing VR immersion levels. Ma and Zheng (2011) propose a simple classification into non-immersive, semi-immersive and immersive VR systems. Non-immersive VR systems compose of a regular graphics desktop workstation with a monitor, a keyboard, and a mouse. Semi-immersive systems use a higher-performance graphics computing system coupled with one or more large monitors or projectors, providing a more panoramic view. Finally, immersive systems utilize the input and output devices discussed in section 5.2.2 to provide a multisensory experience that envelops the user.

However, there are shortcomings to Ma and Zheng's (2011) classification. One could argue that as non-immersive and semi-immersive VR systems are, by definition, not immersive, they are nonessential. Moreover, the classification is somewhat device-specific and omits, for example, hand-held displays, which are currently a common way of experiencing simple VR. More importantly, the classification does not offer ways to determine the relative immersion level of "properly" immersive VR systems.

For the purposes of this study we therefore use the following rule of thumb for assessing the immersion level of VR systems: system A is more immersive than system B if system

A can be used to simulate system B (University of London 2020). By this account, a modern HMD-based VR system is more immersive than a simple VR CAVE, since using a CAVE could be simulated within an HMD, but not the other way around. The same rule of thumb applies to the non-immersive and semi-immersive systems discussed by Ma and Zheng (2011) – a semi-immersive system could simulate a non-immersive system, and an immersive system could simulate them both. However, fundamentally different VR systems cannot be assessed according to this maxim.

Figure 21 depicts further examples of how relative immersion levels could be assessed. It builds on the previous discussion on immersion levels, giving concrete examples of how various VR systems could be ranked in terms of immersion. The authors' learnings of VR and hands-on testing of VR solutions were also used to compose this depiction.

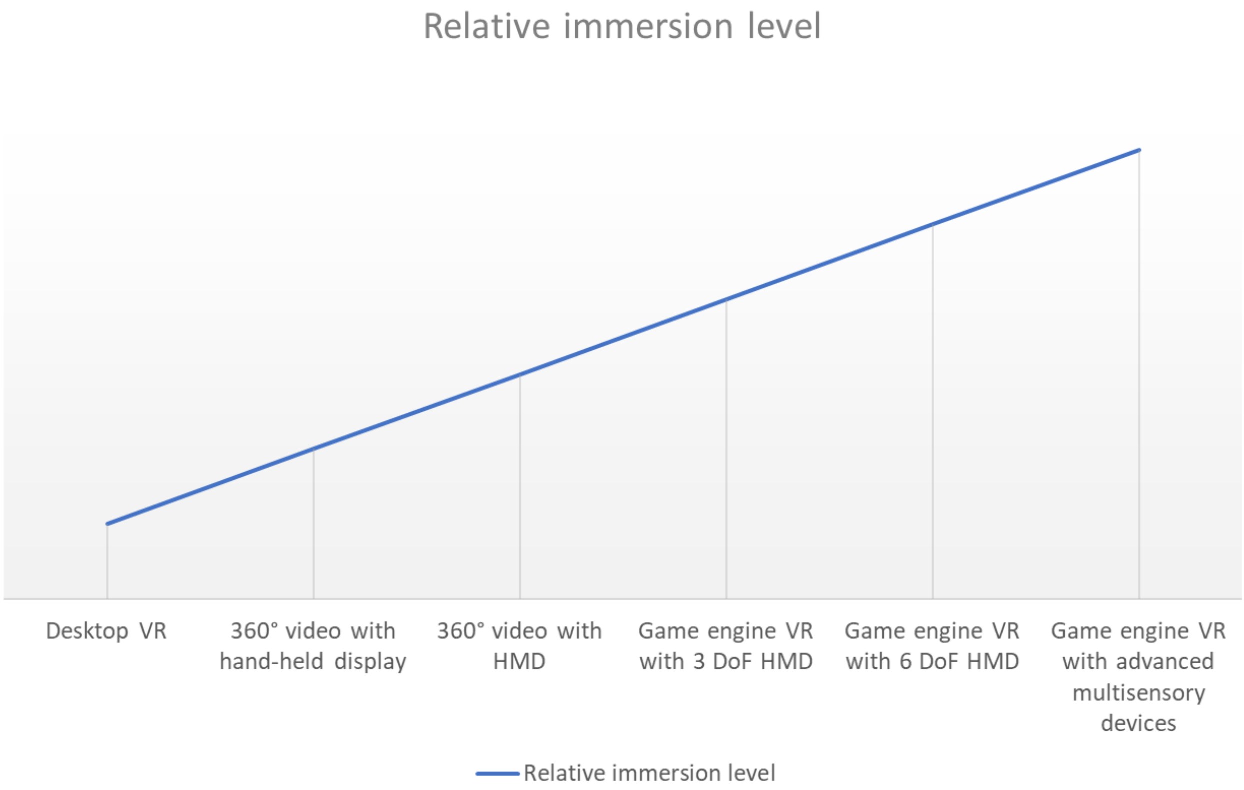

Figure 21. An approximation of the relative immersion levels of different VR systems. VR systems with a higher Y-axis placement must be able to simulate the systems below them.

5.3.2 Fidelity

Besides the level of immersion a VR system can deliver, other design and implementation choices greatly affect the VR experience. Many of these concern *fidelity*: how closely various aspects of the VR system resemble the real world. Fidelity choices provide a backdrop to the immersion prerequisites, as is depicted in grey in Figure 20. This section takes a closer look at different aspects of fidelity.

Figure 22 shows three fidelity continua: representational, interaction, and experiental. These are summarized here based on Jerald (2016, pp. 50-52). *Representational fidelity* concerns the realism of the VE: this ranges from purely abstract environments (consisting only of symbols, sounds etc.) to photorealism. *Interaction fidelity* concerns how well physical actions in VR match those performed in the real world. For instance, if VR is used to demonstrate competence in a real-world physical task, interaction fidelity must be high. Then again, VR enables the use of simple, button-press-like actions for complex tasks or even magical techniques for use cases where high fidelity is not required. Finally, *experiental fidelity* describes the degree to which the user's experience matches the VR creator's intended experience. It is important to note that no point along these fidelity continua is inherently better – placement goals must be chosen based on project objectives.

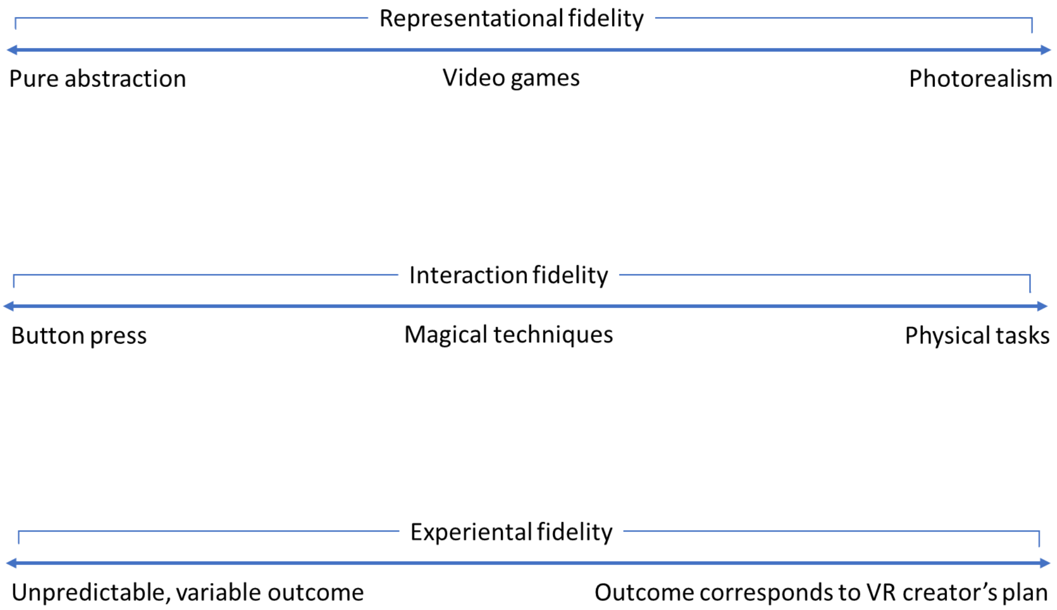

Figure 22. VR fidelity continuum (based on (Jerald 2016, pp. 50-52)).

Since this study examines the care industry, the fidelity of human characters in VR is particularly salient. It has been suggested that people's emotional reaction to humanlike characters develops favorably until a relatively high but imperfect human likeness is achieved (Ho, MacDorman 2010). For example, a humanoid robot may be experienced favorably. After a certain point, reactions suddenly turn negative. This sudden dip is termed the Uncanny Valley, and it is depicted in Figure 23. Characters' movement is thought to intensify the dip (shown as a dashed line), a proposition which should be considered in designing VR experiences. It may be better to settle for lower-fidelity characters than chance ending up in the Uncanny Valley because of a “zombie effect” where an eerily imperfect human character provokes feelings of repulsion in VR users. Favorable reactions to humanlike characters recover once near-human likeness is achieved.

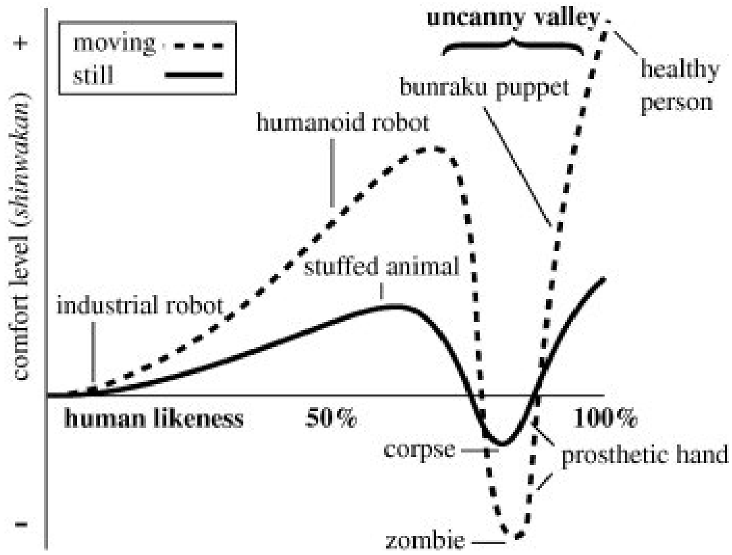

Figure 23. The Uncanny Valley (cited in (Ho, MacDorman 2010)). The observer’s comfort level is dependent on the character’s human likeness. Movement intensifies this relation.

5.3.3 Presence

The final key concept in experiencing VR is *presence*, shown in purple in Figure 20. Presence is “a state of consciousness, the (psychological) sense of being in the virtual environment” (Slater, Wilbur 1997, p. 4). It can also be defined as the tendency of users to respond to virtually generated sensory data as if they were real (Sanchez-Vives, Slater 2005). This latter definition usefully emphasizes the fact that users are active agents in VR.

Presence is therefore psychological and bodily state of the user. It is largely subjective, as opposed to immersion, which describes the VR system’s objective technological characteristics. The system’s level of immersion and fidelity choices facilitate or limit presence but cannot alone guarantee it; it is dependent on each individual user. VR literature includes numerous operationalizations for presence, not all of which take this user-dependent view. It follows that there are currently no commonly agreed measurements for presence; its existence and quality are usually studied via different questionnaires (Slater, Lotto et al. 2009).

Presence can easily be broken. This undesirable effect is called a *break-in-presence* and it can be caused by any glitches that affect the user, for example discontinuations in tracking, hearing real-world noises, or ill-fitting HMDs which allow the user to glimpse the real world (Slater, Steed 2000).

To enable the feeling of presence in a non-existent, computer-generated environment, the user must succumb to various forms of illusion: the illusion of spatial presence (also known as place illusion), self-embodiment, physical interaction, and social interaction (Jerald 2016, pp. 47-49). For the purposes of this study, the illusion of social interaction is especially interesting. Social interaction can happen between user-controlled characters or between user- and computer-controlled characters. A VR study on speech anxiety, a form of social phobia, found that even low-fidelity computer-controlled characters with pre-programmed behaviors caused users anxiety responses that corresponded to those in the real world (Slater, Pertaub et al. 2006). This demonstrates that the illusion of social interaction in VR does not necessitate high-fidelity photorealistic characters.

5.4 VR and competence recognition

To understand the potential uses of VR in competence recognition, it is useful to consider how the medium of experiencing relates to the human experience. Dale's Cone of Experience (CoE) is a non-scientific model dating from the 1940s, used for illustrating experiential learning and how the medium of learning affects learning outcomes. An adaptation of the CoE is shown in Figure 24. Learning mediums progress from concrete, hands-on experiences to abstract, symbolic communication. The more abstract an experience is, the weaker the basis for learning that can be meaningfully transferred to concrete actions in the real world. Conversely, if the medium of experiencing is personal, empirical, and multi-sensory, there is greater potential for learning that also manifests itself on the level of motor skills and affective qualities, not only cognition. The parallels to, for instance, the Bloom's taxonomy domains (see Section 3.2) are noteworthy.

Since the CoE was first drafted, media technology has moved on significantly. The model was therefore updated to the Multimedia Cone of Abstraction (MCoA) (Baukal 2013), parts of which are included in Figure 24. VR is placed at the bottom of the MCoA pyramid, representing the medium with the most potential to offer direct purposeful experiences and consequently the most multifaceted learning. Baukal states that user-controllability is central to why VR experiences are so potent and speculates that photorealistic VEs provide higher representational fidelity and may therefore be more powerful in terms of learning. This potential is widely utilized in vocational training for instance in the aviation, automotive, and military industries, but also in the service industry. This is exemplified by retail giant Walmart, for whom VR is a standard part of employee training, especially in simulating challenging scenarios like a Black Friday shopping rush (eTail 2020). However, Baukal (2013) notes that in some VR use cases, such as anatomy training, simulations with lower representational fidelity may be preferred.

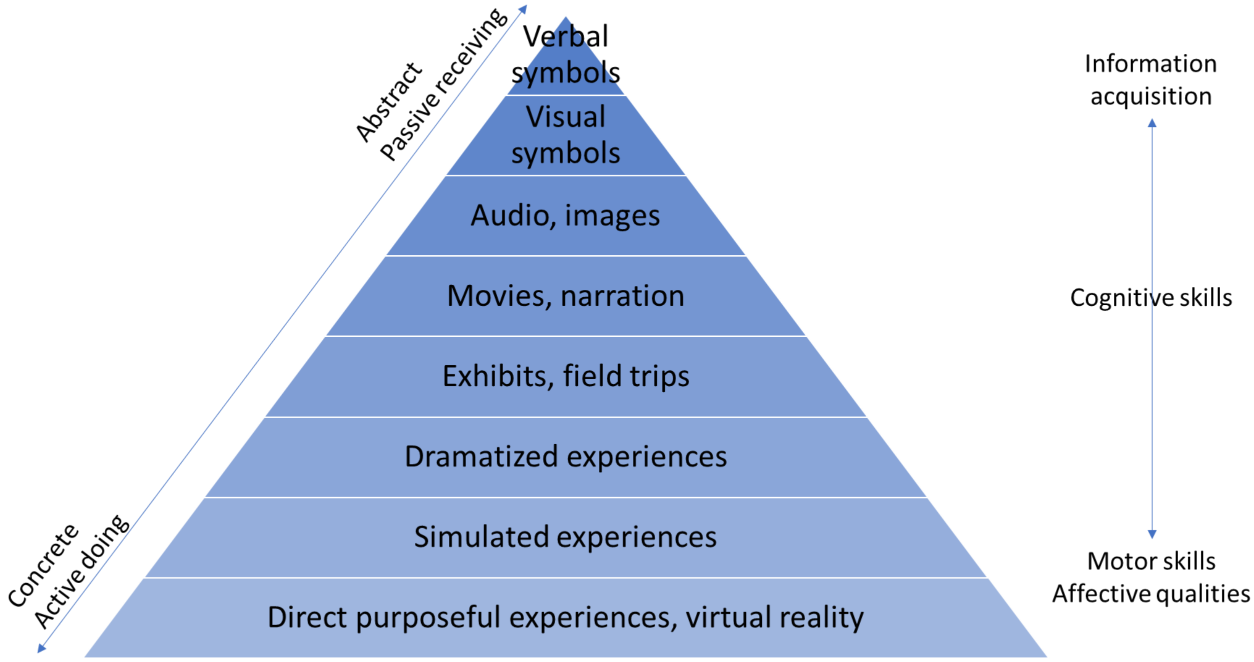

Figure 24. A composite of the CoE (cited in (Jerald 2016) p. 13) and the MCoA (Baukal 2013).

VR offers the opportunity for embedding higher abstraction level objects (symbols, audio, images etc.) into a VE to complement it in ways that are not possible in the real world. Moreover, interaction fidelity is fluid in VR, enabling, for instance, magical techniques in psychomotor task performance. One might speculate that these novel possibilities could enhance both learning and competence recognition on several levels of abstraction. The CoE and the MCoA suggest VR could be a promising medium for demonstrating existing competences, especially when they are not purely cognitive and their execution in the real world could pose problems. An open question is how advanced the VR implementation should be in such cases to allow the true recognition of concrete learnings, motor skills and affective qualities. In a highly limited VE with low representational and interaction fidelity, the user might not have the possibility to adequately demonstrate more complex competences.

5.5 Current challenges

XR, let alone pure VR, is yet to go mainstream. Many visions thought up by decades of science fiction writers remain just that – visions. More widespread use of VR needs major investments and developments not only in technology and human-computer interaction (HCI), but physiology, neuroscience, psychology, philosophy, law, and other fields relating to the topic. Some of the current challenges in different aspects of VR are introduced below.

5.5.1 Health concerns

Some of VR's biggest challenges are related to its numerous adverse health effects. Widespread VR success is unlikely if users run the risk of nausea, dizziness, eye strain, seizures, physical injury, or disease transmitted via shared devices – these are excerpts from the six-page health and safety warnings document that accompanies the consumer-targeted Oculus Quest HMD (Oculus 2020b). The device should not be used if one is impaired in any way, for instance due to lack of sleep, since this may increase the likelihood of adverse effects. Moreover, pregnant, elderly or people with heart diseases, psychiatric problems or other serious medical conditions are asked to consult their physicians before using the device.

VR sickness is any sickness caused by VR use, regardless of the exact cause of that sickness, which include, among others, sensory inconsistencies, eye strain, and device problems (Jerald 2016, p. 160). VR sickness is a broader term than motion sickness or cybersickness, which are often used synonymously in VR literature.

Jerald (2016, pp. 197-205) classifies VR health concerns into system factors, application design factors, and factors related to each individual user. These are often interwoven in complex ways and problems may only appear when certain factors combine. First, system factors are such that engineering progression will likely overcome them at some point. Latency, or the time it takes a system to respond to a user's action, is the greatest systemic problem. Other system factors include problems with calibration, tracking accuracy and precision, and display qualities such as flicker and judder. Hardware problems such as device fit, and hygiene are also system factors.

Second, problematic application design factors pertain to the content of the VR experience, and include the user not being in control of their movement, visual accelerations, prolonged experience duration, arm fatigue, and having the user stand up instead of sitting down (Jerald 2016, pp. 203-205). Third, there are factors related to each individual user that increase the risk of adverse effects. Besides those listed above when discussing Oculus' health and safety warnings, these include the propensity for motion sickness, no prior VR experience, anticipating being sick, the female gender, strong prior expectations towards the VR experience, and poor balance (Jerald 2016, pp. 200-203).

5.5.2 Diversity concerns

The existence of diversity issues in the technology industry related to developer and user qualities such as gender, age, ethnicity, or sexual orientation is widely acknowledged and the harmful effects manifest throughout the product lifecycle (Hallamaa 2020). There is no reason to assume that VR design, implementation, use, and content would be immune to these issues. Serious biases and failings can embed themselves in technology if diversity is not consciously considered throughout its creation.

Relating to the health concern discussion above, VR sickness is, in general, more common in females, and one reason is thought to be the bad fit of HMDs to female bodies (Stanney, Fidopiastis et al. 2020). This may be because VR devices are often designed by adult male engineers and thorough testing with users of other ages or genders may not always be performed. However, not all studies have found gender differences in VR sickness incidence (Saredakis 2020). Yet it is possible that gender-based challenges exists, and conscious inclusivity efforts are required to eliminate them. VR sickness may also increase with age, which may be due to an age-related increase in balance issues and vertigo (Brooks, Goodenough et al. 2010). This should be considered in VR application design.

Other diversity threats also exist, among them cultural issues. If VR technology and content is created by a culturally homogeneous team, it may not be relevant or may even be offensive to users of other cultural origins. Even when the well-meaning intention of VR content is to promote empathy, the outcome may feel insensitive to viewers from marginalized groups (Nakamura 2020). Nakamura notes that combatting this problem requires more diversity in the whole VR chain of command, not only including marginalized groups in VR content creation. Moreover, cultural viewpoints must be considered in VR device design, for instance so that HMDs are comfortably usable with different kinds of headwear.

5.5.3 Unsatisfactory interaction methods

Human interaction is mostly nonverbal and often quite subtle. VR is not yet able to meet this challenge. This section has already remarked upon many of the challenges VR faces in this regard, for example concerning the preeminence of sight and sound over other senses and the inadequate quality of haptics. Fundamental technological features such as speech recognition are also still a work in progress, not to mention more advanced features like the interpretation of human gestures or the natural use of a user's physical body in VR.

If there are shortcomings in enabling the functional aspects of interaction, taking into account inter- and intra-user emotions is even more distant. Various workarounds have been suggested to allow emotional expression on a rudimentary level, including simple pre-programmed avatar gestures and expressions, but their interpretation is difficult, and they might be cumbersome to use, thereby hindering the overall VR experience (Nguyen, Duval 2014). It is also thought that emotional VR experiences correlate with increased feelings of presence, but the connection and its variables are not yet fully understood (Diemer, Alpers et al. 2015).

5.5.4 Hardware shortcomings and smartphone VR

The technical capabilities, ease and comfort of use, and expense of VR hardware is yet quite immature. For instance, more specialized VR input and output devices are often bulky, cumbersome to use and only available in dedicated laboratories. Sophisticated finger tracking is not yet commercially available, let alone full body tracking or naturally interacting with others' bodies. VR hardware is currently often visually and/or auditorily oriented, while the real-world human experience is much more multisensory. Convenient consumer-grade hardware is therefore required for VR to succeed in the mass markets.

On the other hand, modern smartphones offer ways to experience VR on a low immersion level without much additional hardware by using the likes of Google Cardboard. This competition factor must still be considered, even though phone-based VR has been declared a thing of the past, and certainly has not proliferated to the degree expected by some (Robertson 2019). If consumers are content with using smartphone VR, their incentive to even explore more advanced VR devices declines. Yet the immersion level of smartphone VR is relatively low, so it cannot accommodate more demanding use cases, and in the worst case technologically inadequate devices can exacerbate VR's adverse health effects.

5.5.5 Cost and availability issues

The cost of purchasing or developing VR hardware and software, especially those allowing higher levels of immersion, remain at a relatively high level. Consumer prices range from around 200 € for simple standalone headsets with 3DoF to thousands of euros for more sophisticated devices, and the same goes for tethered devices (Wikipedia contributors 2020c). Multisensory VR experiences are de facto not yet commercially available.

However, if technological progress follows its current accelerating path, it is likely that features will advance, and prices will come down sooner or later.

Another current problem is that those convenient and reasonably priced VR devices that do exist face availability challenges. For example, the Oculus Quest HMD is regularly sold out due to demand and manufacturing issues (Johnson 2020).

Each VR device can only be used by one person at a time, and their sharing is problematic for instance for hygiene reasons. Moreover, device use requires the presence of an overseer, so use costs are also not negligible.

5.5.6 Standardization and centralization issues

Lack of formal standardization is a problem both for VR development and potential consumers. Although de facto standards may exist, they are often proprietorial. Open standards agreed upon and developed equally within the VR community do not exist. For these reasons, interoperability between software and hardware is not guaranteed, and product comparison is difficult. Similarly, open source development is lacking, and major R&D efforts are often centralized, since developing advanced VR is still resource intensive.

However, initiatives exist that aim to remedy these issues. Open Source Virtual Reality (OSVR) attempt to provide a software development kit that supports all VR hardware in one go (OSVR 2020). OpenXR develops standards for an application programming interface and an abstraction layer for VR devices, providing an interface between VR applications and their runtime environment (The Khronos Group Inc. 2020). Notable technology companies such as Facebook, Google, and Microsoft have contributed to OpenXR.

6 VR use cases for competence recognition tasks

Chapter 4 presented the VR Fast Track competence recognition framework, including examples of competences that should be validated in concrete tasks performed by a job seeker. The core idea was that these tasks would be performed in a VE, enabling the job seeker to demonstrate their skills in action. Chapter 5 outlined the basics of VR and how this thesis views its relevance to competence recognition. This chapter provides examples of how competence recognition tasks were formulated into VR use cases.

A high-level idea in this study was to create a library of VR tasks – some general and some industry-specific. Hiring companies could use this library to select tasks to build competence recognition curriculums to suit their specific, and often changing, needs. A library with a flexible structure allows adaptation, making it possible to assess only specific competences, also on different levels if required. Or if a certain competence is not applicable to a specific job role, it can be left out altogether. The library idea will be further outlined below using a care industry-specific example labeled the “Care curriculum”.

Moreover, a foundational thought was that use cases exist on different levels depending on the desired level of user interaction: there can be several manifestations of a similar competence recognition task on different interaction levels. Hiring companies could focus on such a level that they currently have the need and the resources for.

This user interaction-based progression is shown in Table 4. Level one represents the user as a spectator. Level two adds simple interaction with the system via gestures such as pointing or selecting. On level three, the user performs concrete actions, such as manipulates items. Finally, on level four these concrete actions are performed with other users. These levels are conceptual, not technological. However, this division can be used to understand the technological immersion level, discussed in section 5.3.1, that is relevant for implementing a use case.

In this thesis, one detailed use case example, “Spot the problem”, was prepared. On the scale in Table 4, it represents user interaction level two. The target level was agreed with the VR Fast Track project based on its needs and resources.

Table 4. The progressiveness of VR use cases as seen through user interaction in a virtual environment.

Level	Description
1	User observes a situation.
2	User reacts to a situation by simple gestures (e.g. pointing/selecting/speech/bodily gestures).
3	User performs concrete actions (e.g. manipulating items).
4	User performs concrete actions in collaboration with others.

This chapter goes over the process of use case creation and presents its outputs. First, a user persona representing the job seekers is defined. Next, the "Care curriculum" is presented, followed by the general use case template and the finalized use case, "Spot the problem". It is noteworthy that both the curriculum and the use case documents are included as appendices due to their mode of presentation, but their content is described in this chapter. The chapter concludes with an overview of the current implementation feasibility of VR competence recognition use cases, first in terms of the "Spot the problem" example, and then more generally.

6.1 Development process

Use case development relied on the VR learning gained in this study and presented in Chapter 5, along with the authors' previous knowledge of IT systems development, including experience with non-VR use case definition and implementation. In addition, hands-on tests of over-the-counter VR solutions were performed using a standalone Oculus Quest HMD, which is a relatively advanced commercial device with 6 DoF. Oculus tutorials, demos, and Haaga-Helia UAS's material were tested. This experimentation helped to understand what is currently feasible in commercial VR and how the scenarios should be designed. For example, in VR one must consider many more directions and orientations than in non-VR systems, and these must be included in the design documentation. The same goes for the more multifaceted interaction between the user(s) and the system.

The Oculus Quest experimentation showed that learning to naturally wear a headset and operate in a VE takes time. Simply wearing an HMD was somewhat intimidating to begin with, and one had the urge to remain seated to avoid accidents resulting from faulty coordination. In the tests, hand-held controllers that simulate human hands were used. Understanding, let alone becoming adept at how to point at, select, grip, and release objects required quite a lot of familiarization. It was not helped by the fact that the solutions differed in their manipulation details.

Even though the different tested environments were more or less immersive, some being 360° videos and some game engine VR implementations, they were generally not very presence-inducing. Many of the game engine solutions were very rudimentary and their use did not feel smooth. Also, the added value of watching 360° videos on an HMD was not necessarily high compared to watching them on a non-VR device, especially if one could not navigate in the VE. However, testing a boxing solution demonstrated that even an animated character can trigger real-life physical responses in a user, suggesting a degree of presence.

Based on these tests, a twofold approach for this study was proposed and approved by the parent project. First, such VR competence recognition tasks would be imagined were anything is possible (within the limitations discussed in Chapter 5). Second, a use case would be composed that could realistically be implemented within the VR Fast Track during autumn 2020.

6.2 User persona

The service design process started by creating a user persona – an archetype representing the study's target group – for the competence recognition tasks. Creating personas is a common service design tool, and its goal is to help create better solutions to real-world problems through understanding users' motivations and behaviors (Stickdorn, Hormess et al. 2018). It is common to create several personas, but in this study, it was decided to only create one persona. This was done to focus on the user group that, based on the collected learning, was thought to benefit most from VR-based competence recognition. Additional personas should be developed later by the VR Fast Track project.

The user persona is shown in Figure 25. She is an adult job seeker in the care industry with no higher education and only basic skills in Finnish or Swedish. She is accustomed to smartphones, but otherwise her IT skills are elementary. She has informal care experience and would prefer to show these skills in concrete tasks.

<table>
<tr><td>Persona:
Job seeker in the care industry
</td><td>Basic description:
- 30 + years
- Limited elementary school tuition, no higher education
- Informal experience of elderly care
- Highly motivated to find employment
- Would prefer to demonstrate practical skills rather than verbally describe them</td></tr>
<tr><td>Challenges:
- Basic skills in target job language
- Basic textual and numerical know-how with Latin alphabet and Arabic numerals</td><td>Attitude towards VR:
- No prior experience of VR
- Very basic IT skills: mainly smartphone use
- Interested in experimenting with VR, open to new experiences</td></tr>
</table>

Figure 25. The user persona for use case development.

6.3 Care curriculum and the VR task library

Appendix 5 presents the “Care curriculum”, a fictional example of VR competence recognition tasks that a company seeking to hire care workers might have chosen. Its purpose is to show a real-world example of how the prospective VR task library could be utilized by hiring companies.

The tasks are ordered into named sequences. A sequence may be general, like the “Spot the problem” sequence in this example, or industry-specific, such as the “Caring for a customer refusing to…” sequence. The implementation details of even general sequences may of course vary according to employer needs.

The sequences' difficulty is linked to the competence recognition framework’s levels (1 to 4). Within the curriculum, the difficulty increases incrementally. The “Care curriculum” starts with a tutorial familiarizing the user to the VR environment and testing the competence of spotting health and safety risks, and advances towards managing difficult situations where the customer is acting aggressively. Although the sequences build on each other in terms of difficulty, the idea is that a progressive path through the curriculum is not always necessary, depending on employer and applicant needs. Higher-level sequences can therefore also be run separately, and their completion will cover the levels below for the competence that was being tested.

Each sequence may include several tasks, and each task may include the testing of different competences from one or more difficulty levels of the competence recognition framework. The goal is for the curriculum to have direct links to the competences listed in the appropriate industry-specific recognition framework. In the example in Appendix 5, the "Framework link" column thereby links to the last column in Appendix 4. This means that the "Spot the problem" sequence might test the following competences on level 1: cognitive 1.1 (COG 1.1) and pair and team work 1.1 (PAW 1.1). The first numeral relates the framework difficulty level and the second the running number of the competence within each competence dimension (cognitive, psychomotor, affective, and pair and team work).

Appendix 6 illustrates a draft of a VR task sequence card. These individual cards would form the VR task library for the hiring companies to select from. It gives an overview of the expected outcomes and tested competences of the sequence and includes a description of its possible implementation on the right-hand side. The example in Appendix 6 presents the "Spot the problem" sequence.

The competence recognition task library and its use for building company-specific curriculums should both be developed further. This study only drafted initial ideas for their format and use, with a focus on how they could be linked to the competence recognition framework.

6.4 Use case template

To proceed with use case design, a use case template was required. No pre-existing, commonly used templates were found for VR use case design; they were sought for online and in selected VR books. This may reflect the fact that best practices have not yet formed in this relatively young IT sector.

Consequently, a template was developed, and it can be found in Appendix 7. This template is designed to serve the VR Fast Track project for creating use cases also after this study, regardless of industry. The template attempts to provide all information regarding a specific use case. It is designed to be industry-independent and provide direct links to the competence recognition framework. This helps to build a coherent whole and the necessary audit trail from employee role-based competence definition, all the way to technical implementation.

The template especially serves technical developers and testers, but it also provides a detailed description of the use case scenario to hiring companies. Since this study used a service design approach, all stakeholders' viewpoints were important. This is reflected in the template, which includes separate sections for defining the use case's user story as well as its business purpose. User stories, in particular, are a common service design tool (Stickdorn, Hormess et al. 2018).

The main use case flow is presented as a user-system interaction, an approach that is common in non-VR use cases and thus familiar to many developers and testers. The same familiarity factor motivated many of the other sections, such as those describing alternative flows, preconditions, dependencies, and non-functional requirements. The different use case sections may link to each other: for instance, the template's main use case flow includes exemplary links to descriptions of alternative flows (abbreviation A, followed by running numbering), additional information (I), metrics (M), and competences (C). Using these links helps to structure the template and avoid information duplication.

To link use case functionalities to the competence recognition framework, a separate section was included for defining which competences the use case examines. The competences listed in this section are directly linked to the righthand column of a field-specific application of the framework (an example of which is seen in Appendix 4). The use case should also define the priority and measurement scale of each competence. This information is needed for scoring use case execution.

The template also includes sections on metrics being monitored during task execution and their aggregation into a competence profile for the purpose of scoring the user and allowing the comparison of scores between users. This aggregation also takes into consideration the aforementioned competence definitions. The need for building a competence profile was recognized in this study, but its realization was out of scope.

6.5 Use case "Spot the problem"

This study specifically focused on one sequence in the "Care curriculum": Spot the problem. Due to constraints in off-the-shelf VR, the resources of the VR Fast Track project, and the fact that the project partners with a creative agency with a capability of creating 360° videos, it was decided to focus on a relatively simple use case whose implementation was feasible at this point in time. This use case was such an option, while still providing a firm link to the competence recognition framework and thus holding promise for delivering value to partnering companies' recruitment processes.

The "Spot the problem" use case can be found in Appendix 8. This finalized version is designed in such a way as to be ready for implementation using a 360° video approach, although it could naturally also be implemented using more advanced VR technology.

The use case includes the basic interaction flow between user and system, as well as descriptions of how to handle erroneous or alternative flows. It describes a selection of the occupational health and safety problem hotspot options that are meant to be spotted in the use case. These options have been selected based on research on real-world care industry health and safety risks. The use case also gives specifications on audio, symbols, lighting, navigation, and other properties that were considered necessary for technical design and implementation.

The section for competences is incomplete in terms of the framework links, which are only illustrations, and the competence measurement scales. The section for scoring is similarly unfinished, since building the competence profile was out of project scope.

During earlier iterations of this study, a less constrained approach was also applied, in which project resourcing or the current implementation feasibility did not pose rigid restrictions. This was done to develop a more varied feel for the possibilities of VR in competence recognition, and to try out a different, movie script-inspired approach to use case writing. This unfinished alternative draft of the "Spot the problem" use case is included in Appendix 9. Its implementation would likely require game engine-based VR development and would thus be more resource intensive. It was also not clear whether the VR Fast Track project would have game engine developers available. Moreover, the script style use case was deemed less useful by the parent project, so this version was not developed further. It is noteworthy that this draft does not include all the sections of the finalized use case template.

6.6 Implementation feasibility

This section discusses implementation feasibility on two levels. First, it analyses the possibility of implementing the "Spot the problem" use case within the VR Fast Track context. Second, a more general look is taken at the opportunities of VR in competence recognition.

The “Spot the problem” use case was designed to be relatively straightforward and technically uncomplicated. It only involves simple user interaction (level two on the scale in Table 4). Its implementation feasibility using 360° video technology has been validated with a VR specialist working for the VR Fast Track project. The good availability of hardware and software that support 360° videos makes its implementation within the project wholly feasible.

However, the immersion level of 360° videos is lower than that of more advanced VR technologies, especially if experienced via unsophisticated devices. Moreover, they only allow limited interaction possibilities – mainly through simple hotspots. Therefore, it is likely that the presence-inducing effects of the eventual “Spot the problem” solution will be quite low. Then again, a benefit of focusing on 360° videos is that they can also be executed on desktops or smartphones. In this way, competences can also be tested without expensive or potentially hard-to-acquire VR equipment or the support and guidance of a VR expert during task execution. Furthermore, testing the use cases becomes easier and a broader test user base becomes available. These are important considerations for the VR Fast Track project.

Table 4 structured the progressiveness of VR use cases through user interaction. The implementation feasibility of levels one and two, representing spectatorship or simple interaction with the VR system, is already good even using off-the-shelf VR hardware and software. However, the implementation of use cases on levels three and four, where the user performs concrete actions either individually or with others, remains resource intensive and requires advanced custom programming and typically also purpose-built hardware of such complexity that it is essentially unavailable outside dedicated laboratories. So, while these levels provide much more varied options for competence recognition, they require such advanced technological features that their implementation feasibility is much lower.

Figure 26 visualizes the feasibility of using VR in competence recognition more detail. It shows an approximation of the current availability of various technological features. This availability is then related to the cost and work effort of using the feature in building competence recognition tasks. The idea is that VR competence recognition projects utilize these ready-made hardware and software features – they are not VR technology development projects as such. For example, the tracking of bare hands is a specific technological feature that is developed by dedicated companies and may one day be a part of many off-the-shelf VR products. When the technology matures, it will ease the building of competence recognition tasks.

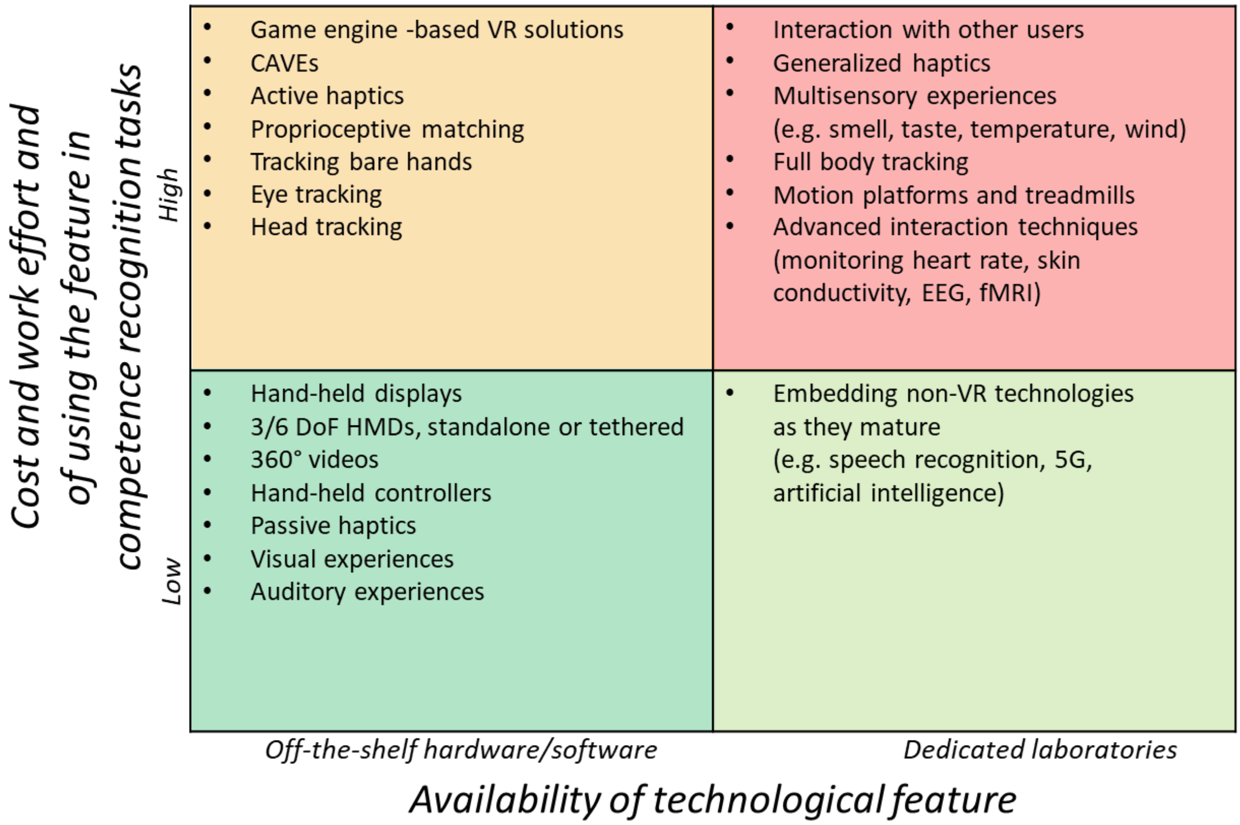

Figure 26. The relationship between the availability of various technological features (x-axis) and the cost and work effort of using these features in building VR competence recognition tasks (y-axis). Dark green elements are currently widely available, and their use is straightforward and resource efficient. Dark red elements remain constrained to dedicated laboratories, and their use is prohibitively resource intensive.

The dark-green scenarios in Figure 26 only require simple visual and auditory experiences, or perhaps the use of technologically simple passive haptics. Using these features is already feasible with a low to moderate work effort and only off-the-shelf hardware and software. The technological puzzles of the orange features, like active haptics and the tracking of eyes and bare hands, have been solved up to a point, but the utilization of these solutions still requires the purchasing of dedicated hardware and software and/or a high amount of adaptive work. The advanced dark red features, such as multisensory experiences, meaningful user interaction, and full body tracking, remain beyond commercial feasibility, de facto requiring experimental laboratory circumstances. Finally, the light green block includes examples of non-VR technologies such as artificial intelligence (AI) and speech recognition. These may be technically complex, but once matured, they will likely be embedded into off-the-shelf VR products and thus ease the implementation of more complex VR competence recognition scenarios.

7 Real-life application of the process and next development steps

The competence recognition framework deployment process, illustrated in Figure 27, shows how the entire process from target role definition to use case implementation would function in real life. The process integrates the use of all the thesis outputs that were presented in Chapters 4 and 6.

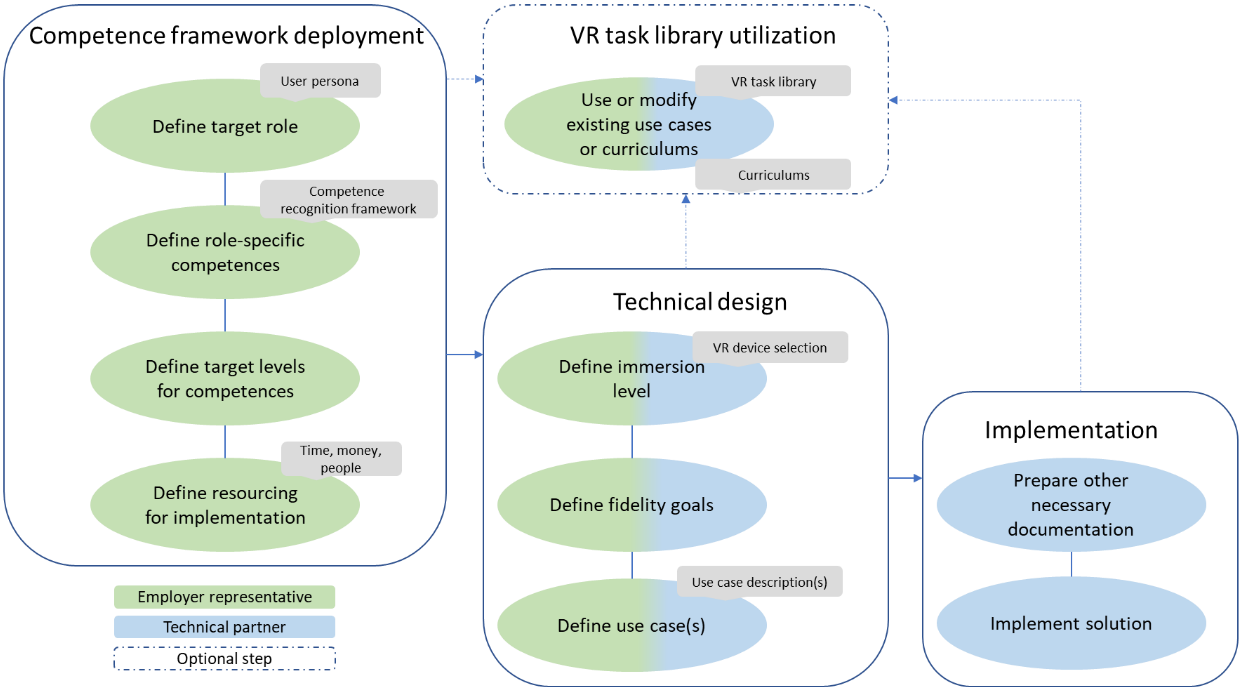

Figure 27: Deployment process for competence recognition tasks.

The process starts with a company having a need for employees. The first step for the employer is to define the target role. What is the prospective employee required to do? Based on this, the employer defines the key competences for the target role. For example, a prospective care worker should be able to spot occupational health and safety risks in the work environment. For this step, the supporting tool is the competence recognition framework. After identifying the competences, the employer should define the target framework levels (1 to 4) for the selected competences.

Once the role, competences, and competence levels are defined, the employer defines the available resourcing. How much time, money, and personnel is available to create the tasks? Who are the people who can work on this project? When the budget is known, collaboration with the technical partner can begin. In this process, technical partner refers to the persons or the company that is responsible for implementing the VR tasks. Together the employer and the technical partner define the immersion level target and select appropriate VR devices. The employer and the technical partner also determine fidelity goals –

how closely the VE resembles various aspects of the real world. Next, they define the use cases required to recognize the selected competencies in a way that can be implemented within the given budget.

The technical partner is responsible for creating documentation and implementing the use cases in VR. Once this is done, candidate screening by the hiring company can begin.

Figure 27 also includes the optional use of the prospective VR task library that was conceptualized in this thesis and presented in section 6.3. If such a library would exist, companies could utilize it to reuse or modify ready-made competence recognition tasks, either partially, case by case, or in a curriculum format. The library could be utilized in all phases of the overall process for these different purposes, hence the three dashed arrows in Figure 27.

This chapter continues by outlining how the thesis outputs will be developed next within the VR Fast Track Project and concludes by providing suggestions for further work.

7.1 Next steps in the VR Fast Track project

The VR Fast Track project will continue the further iteration and development of the general competence recognition framework. The current version provides a solid foundation to build upon, but it should be validated with more partner companies, preferably from different industries. Pedagogy experts should also be consulted to help strengthen its theoretical footing.

The care industry-specific application of the framework requires additional input from subject matter experts to mature. It would benefit from the inclusion of more examples to all the competence dimensions. The VR Fast Track project could involve more of its partner companies to help develop it further.

Applications of the general framework to other fields such as hospitality and transportation have also been discussed with the project. Applying the framework could be easier in fields whose vocational jobs are less heavily regulated and not dependent on licenses or protected occupational titles. Yet in all fields careful definition is required so that all stakeholders agree on the sought-for competence profiles and what kinds of skills should exist on different levels of the framework.

In the final phases of this study, a handover to Krea, Haaga-Helia UAS's creative agency, was performed. Krea, in collaboration with the VR Fast Track project and selected Haaga-Helia students, will continue to develop the VR use cases and their implementation with 360° video technology.

The immediate next steps by Krea are finalizing the use cases in the "Care curriculum" and ideating new ones. As mentioned, Krea will first implement the "Spot the problem" use case. The completed use case should be tested together with partner companies, immigration organizations, and job seekers to understand whether it functions as expected and how it can be further improved.

7.2 Suggestions for further work

A possible next iteration of the general competence recognition framework could be to validate that the included competences are generic enough to cover all potential industries within the EQF levels 1 to 4. A logical next step could also be to expand the framework to cover higher education levels and competences.

Additional user personas should be developed – this was mentioned in this study's research interviews by both immigration organization specialists and Krea representatives. Based on the different personas, existing use cases can be further detailed, and new use cases defined.

The library of competence recognition tasks, conceptualized in this thesis, could be developed further. The library could consist of general competences applicable to all industries, in addition to industry-specific competencies. Employers could then select competences whose testing is relevant for their situation.

The scoring of use case execution by means of building a user competence profile could be examined. The competence profile could be an easy-to-grasp visual illustration that merges results from separate use case execution metrics to help assess the skill dimensions of the user. The dimensions of the competence recognition framework (cognitive, psychomotor, affective, pair and team work, and self-awareness) could be used as a starting point for structuring the profile. The execution metrics themselves also present opportunities for further work: for instance, what kinds of measurements are possible using different VR hardware or software.

The benefit and feasibility of implementing VR use cases could be studied further to help complement the initial analysis presented in section 6.6. For example, implementation cost calculations and technical analyses could be made for scenarios where different VR hardware or software are used.

As off-the-shelf VR technology is still in its early stages, the potential for creating lifelike tasks that measure competences linked with complex topics such as human interaction remains limited. When the technology matures, these possibilities should be periodically re-examined.

Developing the processes regarding the deployment and usage of the competence recognition framework and the related VR tasks, including the library structure, could even be the beginnings of a business idea.

8 Discussion

The relevance of the thesis results, as well as their validity and reliability, are discussed in this chapter. Since the study consisted of two distinct areas – competences and how they can be recognized, and VR technology's potential to support this recognition – this same division is used in this chapter.

Rather than producing definite conclusions or finalized versions of study outputs, this was an R&D thesis that supported the VR Fast Track project. The outputs of this thesis will serve as starting points for further improvement and innovation.

8.1 Competence recognition framework

The objectives regarding competences were:

Compose a synthesis framework for competence recognition based on existing taxonomies with a focus on vocational work

Specify care industry-specific competences for target roles and incorporate them to the composed framework

The key success of this thesis was the creation of the general competence recognition framework. The synthesis framework combines key competence areas from existing learning taxonomies, with a focus on vocational work. The central accomplishments were building the framework with a clear working life orientation and the inclusion of softer, humanistic competences such as self-awareness and teamwork. These competences, related to interacting with others and understanding your own and others' behavior, are crucial in many industries. Their inclusion, as well as the framework in general, also received positive feedback from partner company representatives. The framework supports the future work of the VR Fast Track project.

Care-specific competences for target roles were defined and incorporated into the general framework. However, a shortcoming in this thesis was the lack of subject matter experts in the chosen industry. Both authors specialize in business transformation and new technologies and lack knowledge and experience in care and healthcare. The original research plan was built around the assumption of having partner companies actively involved in defining the roles and competences required for care workers. This involvement did not materialize during the majority of the thesis project despite the authors' repeated efforts.

Partner company reviewing of the study outputs only occurred during later stages of the work. This feedback was highly valuable, and it was taken into account in composing the current versions of the care-specific outputs. Nevertheless, the limited amount of expert collaboration affects the relevance, validity, and reliability of these results.

During the thesis project, information regarding the requirements of the care industry partner companies was vague and contradictory. There were also no realistic opportunities for the authors to clarify the situation since the collaborators were not available. This poses additional problems for the relevance, validity, and reliability of the care-specific results. Given these challenges, the care-specific application of the competence recognition framework should undergo additional development iterations. The same goes for the "Care curriculum". It is crucial for the VR Fast Track project to engage care industry experts in the next phases of their work.

8.2 Usefulness of VR in competence recognition

The objectives regarding VR were:

Define sample use cases for VR-assisted competence recognition based on the created framework for implementation purposes

Assess the benefits and the feasibility of using VR in competence recognition in general and for the specific use cases created in the project

The thesis produced a curriculum model and a use case template for further use and development. Both allow for a standardized approach to future development. The detailed sample use case composed in this study, "Spot the problem", is intended to be filmed as a 360° video. While VR is developing fast, in the case of VR Fast Track it is more feasible to use a more lightweight method such as 360° videos. This way the competence recognition tasks can be implemented swiftly and also be utilized via non-VR channels, making them available to a larger group of testers and potential partner companies.

Research into the possibilities of VR gives an impression of definite potential. However, off-the-shelf VR technology is not yet able to support competence recognition at an optimal level. The available options have limited possibilities for immersion and presence, making the value of acquiring expensive and possibly cumbersome VR equipment questionable.

At its best, VR enables the recognition of practical competences that might otherwise be overlooked. This might apply especially to non-verbal and non-numerical competences. However, reaching this potential requires careful planning during design and implementation. An additional consideration is the target group's experience with VEs, or the lack of it. It could well happen that their focus shifts to coping with the new situation instead of optimally exhibiting their competences.

Cost-effectiveness is not yet good for complex, relatively seldom executed use cases, especially those requiring the use of dedicated VR hardware or development platforms such as game engines. Simpler VR use cases are doable with smaller resources, but they will likely not deliver all the benefits that VR could potentially offer. Multisensory, truly interactive VR experiences are, at present, not viable outside specialist venues.

It could be sensible to target future development efforts at use cases that could benefit several employer processes, such as recruitment and training. For instance, 360° video-based tasks of handling hectic or difficult situations could be used in both processes, making the investment more justifiable.

The emergence of 5G network technology will likely boost VR development and adoption by notably increasing network performance and thereby allowing more complicated use cases. The maturing of AI technology could have similar consequences via enabling more complex VR implementations. AI enables VR implementations that learn from and adapt to user data. AI could improve VR interaction via features like speech and gesture recognition and embedding intelligence into computer-controlled characters or features.

The usability of the development process created in this thesis will increase as VR technologies mature. When highly immersive experiences are available at a reasonable price, VR can realistically be utilized in recognizing competencies. Especially for the care industry, multisensory and interactive tasks involving multiple users are required.

8.3 Study process evaluation

This thesis process had several novel factors. First, Haaga-Helia UAS did not have a lot of experience with combining thesis work with its R&D projects, at least in the degree programs the authors attended. Hence there were no tried and tested methods for organizing such collaborative work. At times this caused uncertainty and unclarity since the authors were not integrally a part of the VR Fast Track project yet tried to develop useful material for them. Occasional problems with information flow meant that the authors were sometimes in the dark concerning new project developments or, for example, stakeholder contacts. The same may be said for the conflicting visions and requirements of the stakeholders. This caused some unnecessary work and frustration. Moreover, project roles and responsibilities were not always clear, which is, in a way, understandable in a fast-moving R&D context. These troubles could be mitigated in the future by ensuring even more frequent contact between students and parent project staff, and by the clear delineation of expectations, roles, and responsibilities.

A second novel factor was the pair work aspect. The authors did not know each other at all beforehand and had differing backgrounds. This turned out not to be a problem. Pair work flowed better than could have been expected and it also provided several benefits. In such an R&D project it was highly useful to be able to brainstorm, compare, and develop ideas together, especially since the authors were not previously adept in the fields in question. One might even ask how relevant outputs just one person could have developed? Moreover, because both authors were responsible and active, it provided a shared support system that was also useful in this agile R&D scenario. A lone student might have felt more separate from the parent project, and in such a scenario closer collaboration with the parent project would have been essential.

Methodology choices posed some difficulties, as the study did not readily mold itself to traditional set-ups, such as conducting interviews or a survey to collect data and then analyzing it to produce results. Instead, information and know-how requirements appeared throughout the study and, conversely, previously conceived plans fell through due to changes in the parent project (e.g. the nonavailability of partner companies or their contradictory requirements). The authors had to adapt to these changes on the fly, so using a flexible research strategy was vital. Service design was also thought to be an appropriate choice since this study’s goal was to produce usable outputs for the parent project.

The study afforded wide opportunities for learning, all the way from academic learning taxonomies to the possibilities of VR software. This breadth meant that deep dives into a specific area were not possible, but a bigger picture was formed instead. It also nicely linked real-life business requirements to innovative technological solutions – a connection that is at the heart of the authors’ degree programmes.

9 Conclusions

A general competence recognition framework was defined focusing on the EQF levels 1 to 4. The framework was validated by the VR Fast Track project.

Examples of care-specific competences for supporting functions were collected and incorporated into the general competence recognition framework. This care-specific application of the general framework was reviewed by VR Fast Track partner company representatives. However, the authors recommend developing the care-specific study outputs further with subject matter experts to increase their usefulness.

Examples of VR-assisted competence recognition use cases were produced. One use case was developed to the point of implementation readiness. A template for designing new use cases was also developed. Additionally, a use case library was conceptualized, and a care-specific example curriculum was drafted based on it. These outputs were validated by the VR Fast Track project.

The study provides an overview of the current possibilities of VR in competence recognition in general and in the context of the VR Fast Track project, as well as a look to the future potential of VR in this area.

The main contributions of the study were:

- A general competence recognition framework
- An application of the general competence recognition framework to the care industry
- A template for VR use cases
- A detailed VR use case example, “Spot the problem”
- The conceptualization of a VR use case library
- An example curriculum of VR use cases for the care industry

The usefulness of these contributions to the VR Fast Track project was ensured by agile project management and maintaining close collaboration throughout the study. Steps were taken to enhance the relevance of the contributions by consulting a wide range of VR Fast Track stakeholders and other specialists to provide commentary and expertise. Nevertheless, all the contributions should be further validated in real-world circumstances and developed further by experts in each topic.

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Appendices

Appendix 1. Informed consent form

RESEARCH INFORMATION

In this MBA thesis study, we explore whether virtual reality-assisted competence recognition could help in supporting and speeding up the employment of immigrants. We attempt to structure a competence framework to suit the needs of specific industries. Virtual reality use cases for competence recognition tasks are then composed based on the framework.

Expert interviews will be conducted to gather data on various aspects of the topic. Interview length is approximately one hour. The interviews will be recorded. Interview recordings and their possible transcripts will only be handled by persons involved in the execution of this study. Direct excerpts from the interviews may be quoted in the thesis and possible subsequent publications, but they will be presented anonymously. Organization names will also be disguised. Interview recordings along with their possible transcripts will be destroyed after the thesis and possible subsequent publications are completed.

The research results will be presented in the MBA thesis, which will be made publicly available and sent to participating organizations. The study may also be used in article publication.

Participation is voluntary and you can withdraw from the study without any consequences at any point either before or during participation by informing the researchers. Participation in the study is not thought to cause any negative consequences.

The study is supervised by Principal Lecturer Jouni Soitinaho of Haaga-Helia University of Applied Sciences.

You may request additional information about this study at any time. Contact details can be found below.

CONSENT TO PARTICIPATE IN RESEARCH

I voluntarily agree to participate in Kaisa Anttila and Eveliina Lindgren's MBA thesis study on "Virtual reality in competence recognition – enabling the employment of immigrants to the care industry" (working title). The purpose and procedures of the study have been described to me in sufficient detail for me to understand and accept them.

If you agree to participate in the study, please acknowledge this by filling out the fields below and delivering the completed form to the researchers.

Location   Date

Name in print

Study contact details:
<contact details removed from public document version>

Appendix 2. Interview guide for an immigration organization (in Finnish)

Aloitus n. 5 min

- Tervehdykset
- Nauhoitus päälle
- Haastateltavan nimi ja rooli
- Kauanko työskennellyt organisaatiossa?

Järjestön/hankkeen työnkuva n. 15 min

- Minkälainen järjestön/hankkeen kohderyhmä on?
    - Kuinka suurta hajonta on, kuinka heterogeeninen joukko?
    - Ikä
    - Koulutustausta
    - Kielitaito
    - Maassaolon kesto
    - Sukupuoli
    - Kulttuurinen/uskonnollinen tausta
- Auttaako järjestö/hanke työllistymisessä/opintoihin hakeutumisessa?
    - Jos auttaa, miten?
        - Miten työkykyä arvioidaan?
        - Tehdäänkö yhteistyötä muiden tahojen kanssa – keiden?

Osaamisen tunnistaminen n. 15 min

- Onko käytössä jotain protokollaa osaamisen tunnistamiseen?
    - Jos on, voivatko jakaa sen meille?
        - Mihin perustuen malli on luotu?
    - Jos ei ole, miten käytännössä hoidetaan? Kuka hoitaa?
- Mihin pitäisi erityisesti kiinnittää huomiota osaamisen tunnistamisessa?
    - Prompteja esim. osaamisen osa-alueet: vuorovaikutus, fyysinen tekeminen jne.
    - Prompteja esim. tunnistamisen tavat: ei-kielelliset tavat arvioida?
- Onko osaamisen tunnistamisessa haasteita?
    - Jos on, mitkä ovat suurimpia?

Maahanmuuttajuuden erityispiirteet? n. 10 min

- Tuoko maahanmuuttajuus jotain erityistä huomioitavaa osaamisen tunnistamiseen?
    - Jos tuo, mitä?
        - Prompteja esim. vaihtelu kohderyhmän sisällä, kulttuurierot, syrjintä, traumatausta
    - Miten tulisi huomioida?
- Miten näet kielitaidon merkityksen osaamisen tunnistamisessa? (Jollei ole tullut esille aiemmissa vastauksissa)
    - Millainen taitotaso vaaditaan vähimmillään, että realistista työllistyä?

VR ja maahanmuuttajat n. 5 min

- Projektissa on ajatuksena hyödyntää virtuaalitodellisuutta osaamisen tunnistamisessa. Millaisia ajatuksia tämä herättää?
  - Prompteja esim. kohderyhmän tottumus teknisiin välineisiin; voisiko olla, että kevytkin tekninen aspekti jopa häiritsisi osaamisen tunnistamista?

Jäähdyttely ja lopetus n. 5 min

- Jäähdyttely: Mitä pitävät erityisen tärkeänä huomioida aiheen tiimoilta?
- Jatkohaastateltava?
- Onko muuta lisättävää?
- Päätös:
  - palautetta haastattelusta?
  - voimmeko olla tarvittaessa uudelleen yhteydessä?
  - meihin saa olla yhteydessä, jos tulee mitään mieleen
  - jaamme työn, kun valmis
  - kiitokset!

Appendix 3. General competence recognition framework

Level	Competence to execute	Requirements by competence dimension	
1	Simple tasks based on general knowledge and skills	COG	Can recall and reproduce basic general knowledge.
		PSM	Can demonstrate basic skills involving tools or manual dexterity.
		AFF	Can take part in basic interaction and focus on other people.
		PAW	Can work under supervision based on instructions or imitation.
2	Simple tasks based on basic field-specific knowledge and skills	COG	Can recall and reproduce basic field-specific knowledge.
		PSM	Can demonstrate basic field-specific skills involving tools or manual dexterity.
		AFF	Can contribute actively to more complex interaction through responding and questioning.
		PAW	Can work with a pair and partially independently based on instructions or memory.
3	Standard tasks based on advanced field-specific knowledge and skills	COG	Can recall and reproduce advanced field-specific knowledge.
		PSM	Can demonstrate advanced field-specific skills involving tools or manual dexterity.
		AFF	Can express and justify opinions and engage in constructive argumentation.
		PAW	Can work with a team and independently and take responsibility for completing own tasks.
4	Non-standard tasks based on analysing situations and creating solutions to specific problems	COG	Can analyse and interpret field-specific and general knowledge to create solutions to specific problems.
		PSM	Can demonstrate adapted field-specific skills involving tools or manual dexterity.
		AFF	Can manage moderately difficult interaction situations.
		PAW	Can oversee others' simple tasks and partake in work process improvement.

Self-awareness skills	Can understand and assess own knowledge and skills and their limits.
	Can explain and justify decisions.
	Can ask for and provide feedback.
	Can recognize and manage own feelings.

COG = cognitive, PSM = psychomotor, AFF = affective, PAW = pair and team work

Appendix 4. An application of the competence recognition framework to the care industry

Level	Competence to execute	Requirements by competence dimension – industry-independent		Care industry-specific competence examples	
1	Simple tasks based on general knowledge and skills	COG	Can recall and reproduce basic general knowledge.	COG 1.1 COG 1.2	Can follow simple instructions Can understand the basics of the Finnish language
		PSM	Can demonstrate basic skills involving tools or manual dexterity.	PSM 1.1	Can perform assisting tasks in washing a customer
		AFF	Can take part in basic interaction and focus on other people.	AFF 1.1	Can fetch help for a grieving customer
		PAW	Can work under supervision based on instructions or imitation.	PAW 1.1	Can work under supervision
2	Simple tasks based on basic field-specific knowledge and skills	COG	Can recall and reproduce basic field-specific knowledge.	COG 2.1 COG 2.2	Can follow field-specific instructions Can understand elementary written and spoken Finnish
		PSM	Can demonstrate basic field-specific skills involving tools or manual dexterity.	PSM 2.1	Can help a colleague wash a customer when instructed
		AFF	Can contribute actively in more complex interaction through responding and questioning.	AFF 2.1	Can listen attentively to a grieving customer
		PAW	Can work with a pair and partially independently based on instructions or memory.	PAW 2.1	Can work as an apprentice with a colleague
3	Standard tasks based on advanced field-specific knowledge and skills	COG	Can recall and reproduce advanced field-specific knowledge.	COG 3.1 COG 3.2	Can recognize the need for further information when following instructions, and look for it Can speak elementary Finnish
		PSM	Can demonstrate advanced field-specific skills involving tools or manual dexterity.	PSM 3.1	Can wash a customer in collaboration with a colleague
		AFF	Can express and justify opinions and engage in constructive argumentation.	AFF 3.1	Can discuss with a grieving customer
		PAW	Can work with a team and independently and take responsibility for completing own tasks.	PAW 3.1	Can work in collaboration with a colleague
4	Non-standard tasks based on analysing situations and creating solutions to specific problems	COG	Can analyse and interpret field-specific and general knowledge to create solutions to specific problems.	COG 4.1 COG 4.2	Can create solutions to problems encountered in daily activities Can communicate in Finnish in everyday situations
		PSM	Can demonstrate adapted field-specific skills involving tools or manual dexterity.	PSM 4.1	Can wash a customer independently
		AFF	Can manage moderately difficult interaction situations.	AFF 4.1	Can console and support a grieving customer
		PAW	Can oversee others' simple tasks and partake in work process improvement.	PAW 4.1	Can work as an equal member of a team

Self-awareness skills	Can understand and assess own knowledge and skills and their limits.
	Can explain and justify decisions.
	Can ask for and provide feedback.
	Can recognize and manage own feelings.

COG = cognitive, PSM = psychomotor, AFF = affective, PAW = pair and team work

Appendix 5. Care curriculum

Care curriculum

Examples!

Industry	Sequence name	Tasks	Competences	Framework link
General	**1. Spot the problem**	• Observe situation • Point out problems in the environment	• Understand the situation and adapt behaviour • Identify basic health and safety problems	COG 1.1 PAW 1.1
Care	**2. Meet a customer (with dementia)**	• Greeting • Introducing yourself • Self-assessment	• Understand the situation and adapt behaviour • Self-awareness	PSM 2.1
Care	**3. Caring for a customer refusing to…**	• Observe situation • Select solution to fix the problem • Explain your solution	• Understand the situation and adapt behaviour • Decide a course of action • Self-awareness	PAW 3.1
Care	**4. Managing difficult situations**	• Stay calm • Reassure the customer • Ask for help	• Ensure own and customer safety • Recognise when to ask for help • Self-awareness	AFF 4.1

Appendix 6. An example of a VR task sequence card

Sequence name: Spot the problem

Task	Competence	Framework level
Observe situation	Understand the situation, adapt behaviour	1
Point out problems in the environment	Identify basic health and safety problems	2

Problem 1:	*Category: Tripping and falling*
Problem 2:	*Category: Housekeeping and hygiene*
Problem 3:	*Category: Ergonomics*

Expected outcome: the user understands how to navigate in the VR environment and use its basic functionalities.
Tested competences: the user demonstrates a basic understanding of health and safety risks and can point them out in a real-world environment.

General competence

<u>VR task description</u>

The purpose of this segment is to familiarize the user to the VR environment. The user will be immersed in the virtual world to explore and test the use of the VR controllers. S/he will be presented with the VR environment functionalities that are required in possible following tasks.

Potential implementation method: 360° video. Get familiar with the VR environment by looking around and navigating in the available spaces. Get to know the controllers -> which buttons to press, how to use hands, how to point and select. Learn how to exit/pause the task and adjust the sounds.

After the familiarization, the user indicates that s/he is ready to begin the actual task. The user looks around the 360° video. Three health and safety problems exist in the environment. The user points these “hotspots” out. The user gets feedback on the selections.

After successfully identifying all the problems, the use case automatically finishes to let the user take a break.

Appendix 7. VR use case template

Use case name: xx

User story
<Summary of the use case's purpose from the viewpoint of the user, formatted as a user story: As a <role> I can <capability>, so that <receive benefit>>

Business purpose
<The business purpose of the use case.>

Scoring
<Explanation of how separate competences (template section: Competence) and metric results (template section: Metric) are compiled and interpreted to form a competence profile of the user.>

Instructions for usage
<General instructions for operating the use case, e.g. instructions for the guide for preparing and monitoring the execution.>

Preconditions
<What is required before the use case can be invoked. *General:* *Technical:>*

Dependencies
<External services / other use cases etc.>

Non-functional requirements
<E.g. usability, no. of simultaneous users, recording capabilities>

Use case example flow

Step	User	System
1	User selects (triggering event)	
2		System opens… (A1)
3.1	User…. (C1)	System… (I1, M1)
3.2	User…	

Alternative	Description
A1	*<alternative flow or exception – explain how use case flow continues/ends>*

Information	Description
I1	*<additional information, e.g. list options, link to wireframe, processing rule>*

Competence	Description	Framework link
C1	*<- competence that is being measured* *- priority/relative importance of the competence* *- measurement scale for the competence (e.g. spent time, error rate, amount/quality of finished tasks, eye tracking, communication…)>*	*<link to competence recognition framework, e.g. COG 1.1>*

Metric	Description
M1	*<metric that is being monitored>*

Open issues
<open issues that are relevant for the use case's implementation>

Version	Date	Author	Change log
V0.1	June 20, 2020		

Appendix 8. VR use case “Spot the problem”, 360° video approach

Use case name: Spot the problem

User story

As a job seeker I want to demonstrate my ability to spot health and safety risks in the work environment in order to get a job.

Business purpose

The user demonstrates basic understanding of domain-specific health and safety risks and can point them out in a realistic virtual environment.

Scoring

<Explanation of how separate competences (template section: Competence) and metric results (template section: Metric) are compiled and interpreted to form a competence profile of the user.>

Instructions for usage

A guide must be present during the length of the task. The guide:

- sets up the VR guardian (safety perimeter) and prepares the task before the user enters the environment.
- explains how to use the controllers and the HMD.
- explains what will happen during the exercise.
- explains that the user can remove the HMD at any time in case of nausea or discomfort.
- monitors task execution and is ready to help with any unexpected situations.

Preconditions

General: Virtual environment based on 360° pictures/video and audio recorded in a real-world location relevant for the target domain. The recording should include several rooms/areas between which the user can move.

Technical: Oculus HMD with hand-held controllers and a safe space for task execution. Additional preconditions will be detailed by the implementation team.

Dependencies

After successfully executing this task, the user understands how to navigate in the virtual environment and use the basic functionalities of the VR system. This is preparation for executing other tasks in the “Care curriculum”.

Non-functional requirements

The guide must be able to follow task execution from a mirroring screen.
Task execution must be recordable.

Use case example flow

Step	User	System
1	User selects option for entering the VR environment (triggering event).	
2		System opens into the largest room/area of the 360° environment (I2, I3, I4). The environment contains the selected problems (I1).
3.1	User looks around to get a sense of the environment.	System continuously updates compass to correspond to user's position (I5).
3.2	User navigates to another room/area.	System responds by navigating to the selected space. (A1, I6)
4	User is ready to start spotting problems and indicates this by pressing the start button (I3).	System begins recording (I7, M1-5).
5	User spots a problem area and identifies it by pointing (C1).	System responds by audio (I2) and highlighting (I4).
6	User spots the last problem and identifies it by pointing (A2, C2).	System responds by audio (I2), stops recording (I8) and fades out.

Alternative	Description
A1	User attempts to navigate along a path that is not pre-prescribed. System does not navigate and responds by audio (I2).
A2	User does not spot all the problems within a pre-specified time limit, e.g. 10 minutes. System responds by audio (I2) and symbol (I3), stops recording and fades out.

Information	Description
I1	Problem hotspot options. Select problems from list and include max 3 per sequence. False hotspots may be included if relevant. <u>Tripping and falling</u> • Water on the floor • Cables/cords on the floor • Rug on the floor with curling edges • Walkway obstructed by incorrectly placed item • Chairs without armrests <u>Housekeeping and hygiene</u> • Litter on the floor • Food scraps on a table • Large open window • Poor lighting <u>Equipment</u> • Sharp object discarded on a table • Medicine bottles discarded on a table

	• Cleaning agent bottle, e.g. disinfectant, discarded on a table • Broken equipment, e.g. wheelchair • Electricity-related hazard, such as complicated extension cord use <u>Ergonomics</u> • Somebody lifting an object in an obviously incorrect way (e.g. a card-board box that is empty < safety) • Somebody crouching down to pick up an object in an obviously incorrect way (from the back, not the legs) • Somebody reaching up to pick up an object in an obviously incorrect way (from a high-up shelf, when assistance should be used)
I2	<u>Audio specifications</u> • Overall: real-world recorded, ambient sounds • Correct hotspot selection: pleasing “pling” sound • Incorrect hotspot selection (if included): unpleasing, short “honking” sound • Incorrect navigation attempt: unpleasing, short “bump” sound • After all the problems have been spotted: fanfare sound • If all the problems are not spotted: sad, flat sound
I3	<u>Symbol specifications</u> Superimposed on the 360° environment. • Largish round button in the user’s field of vision that launches task performance. • Semi-opaque arrows along the floor to indicate possibility to navigate to other rooms/areas • Correct hotspot selection: green checkmark (+ audio) • Incorrect hotspot selection: red cross (+ audio) • If all the problems are not spotted: timeout symbol with text
I4	<u>Lighting/colors/hotspot highlights</u> • Overall: real-world lighting and colors • Correct hotspot selection: highlight object(s) in question. • Incorrect hotspot selection: no highlighting
I5	A compass feature is superimposed in the user’s field of vision (down and to the right) so that the user can always understand his/her position.
I6	<u>Movement/navigation</u> • User can navigate in the environment along pre-prescribed paths by using the controller pointer. • No camera/system-generated movement if possible, to minimize VR sickness.
I7	<u>Record</u> • total task execution time • time spent for spotting each problem • hotspot answers (correct/incorrect) • eye tracking information
I8	The task execution recording must be available straightaway.

Competence	Description	Framework link
C1	Ability to identify domain-specific health and safety problems in the environment. Most important competence to be tested. <- *measurement scale for the competence* >	<*e.g. PSM 2.2*>
C2	Ability to quickly adopt to working in a new environment according to instructions. Secondary competence to be tested. <- *measurement scale for the competence*>	<*e.g. COG 1.1*>

Metric	Description
M1	Number of correctly spotted problems
M2	Number of incorrectly spotted problems
M3	Total task execution time
M4	Average time for spotting the problems
M5	Confidence and accuracy via eye tracking (how the user's gaze travels during task execution)

Open issues

Version	Date	Author	Change log
V0.1	June 20, 2020		

Appendix 9. VR use case “Spot the problem”, game engine approach

Script name: Spot the problem

User Story
As a job seeker I want to demonstrate my ability to spot health and safety risks in the work environment in order to get a job.

Instruction for usage
Purpose of the task: User understands how to navigate in the VR environment and use basic functionalities of the system. User demonstrates basic understanding of health and safety risks and can point them out in a virtual environment. **Instructions:** A guide must be present during the exercise. The guide sets up the guardian (safety perimeter) and opens and prepares the task before the user enters the environment. The guide presents how to use the controllers and the HMD. The guide demonstrates the functionalities and explains what the user will experience in the environment. The guide explains that the user can remove the HMD at any time in case of nausea or discomfort. The guide monitors task execution and is ready to help with any unexpected situations. **Duration:** max 15 minutes

Preconditions
Oculus HMD and controllers and a safe space. Fully virtual interactive environment created on the Unity 3D engine. Technical preconditions will be detailed by the implementation team.

Dependencies
This script should cover all the functionalities required in other tasks of the “Care” curriculum.

Non-functional requirements
Script execution must be recordable. The guide must be able to follow execution from a mirroring screen.

Script
Opening **User POV** User is in an apartment / room. In front is a table with a glass of milk and a dispenser for medication. On the left side is a seating area and on the right is a door to the bathroom and the bedroom. **Above** Ceiling of the room **Below** Floor, carpeted <<Interactivity>> User can move around and explore the space by using controllers, eye tracking and hotspots. User can touch and pick up objects. VOICE [Ambient: Clock is ticking, distant noises of people walking by can be hear occasionally] User looks and moves around to get a sense of the environment and uses virtual hands to reach and touch objects.

After 5 minutes
Fade out

Spot the problem

Fade in

User POV
User is in an apartment / room. In front is a table. On the table is half empty glass of milk, part of whose contents are spilled on the table. On the table are two pills and a pill dispenser, a magazine, and tissues. Customer, elderly person who lives in the environment is sitting behind the table. Customer has a neutral expression on his/her face. On the left side is a seating area and on the right is a door to the bathroom and the bedroom.

Above
Ceiling of the room

Below
Floor, carpeted

Customer: “Hello and welcome” (Task does not contain actual speech, see ref. Sheldon the Sheep for “talking”)

VOICE [Ambient]

<<Interactivity>> There are 3 hotspots (I1) These are the health and safety problems in the environment the user should recognize.

1) There are food scraps on the table -> table is wiped
2) There is water on the bathroom floor ->Floor is dried
3) Medicine on the table -> table is cleared

User points to a problem area. If the selection is correct, a supportive human sound is heard “yes/good”, and the problem area is fixed. If the selection is wrong, nothing happens.

VOICE [Ambient, supportive sound after each correct selection, fanfare sound after all problems have been spotted]

Fade out

Postconditions
After the user has successfully spotted the problems, the sequence ends, and the user can remove the HMD. If the user experiences nausea or cannot spot the all the problems, the guide will stop the sequence. After completion, a recording will be available (technical details provided by the implementation team).

Alternative	Description
A1	User experiences nausea or discomfort → Remove headset, guide will stop the sequence.
A2	User does not spot all the problems within a specific time limit, e.g. 10 minutes. System responds by audio (I2) and symbol (I3), stops recording and fades out.

Information	Description
I1	Problem hotspot options. Select problems from list and include max 3 per sequence. <u>Tripping and falling</u> • Water on the floor • Cables/cords on the floor • Rug on the floor with curling edges • Walkway obstructed by incorrectly placed item • Chairs without armrests <u>Housekeeping and hygiene</u> • Litter on the floor • Food scraps on a table • Large open window • Poor lighting <u>Equipment</u> • Sharp object discarded on a table • Medicine bottles discarded on a table • Cleaning agent bottle, e.g. disinfectant, discarded on a table • Broken equipment, e.g. wheelchair • Electricity-related hazard, such as complicated extension cord use <u>Ergonomics</u> • Somebody lifting an object in an obviously incorrect way (e.g. a cardboard box that is empty < safety) • Somebody crouching down to pick up an object in an obviously incorrect way (from the back, not the legs) • Somebody reaching up to pick up an object in an obviously incorrect way (from a high-up shelf, when assistance should be used)

Competence	Description	Framework link
C1	Ability to spot health and safety risks in a care home environment. Understanding the risks involved. Ability to adapt to and function in a VR environment. Measurement: – Completion: spotting all the problems – Time, the quicker the better – Confidence and accuracy, eye tracking (what the user looks at before pointing an area)	Level 1-2 <Insert link>

Open issues

Version	Date	Author	Change log
V0.1	May 6, 2020		

Appendix 10. Study process log

- Preliminary research based on initial outlines from the VR Fast Track project: what are the competence, training, and qualification requirements for various industries in Finland. The focus was on assisting or vocational positions in care, healthcare, construction, transportation (taxi/bus driver), and security. So-called light entrepreneurship was also explored. This overview was produced to help the project determine a suitable focus industry. The overview was shared and discussed with the project.
- Once the focus industry (i.e. care) was determined: research on the admission exam content for social and health care studies and attempts to ascertain the common national admission criteria for care training. It emerged that such criteria is not available, but schools have their own criteria, which is apparently not necessarily very strongly evidence based.
    - This research phase included an interview with a counsellor of education and information requests to various other relevant actors.
- Preliminary research on existing learning taxonomies. The resulting overview on ten taxonomies or frameworks was shared and discussed with the project. Based on the author's propositions on their pros and cons and the project's comments, 8 taxonomies were chosen for closer examination.
- A project plan was drafted, including study objectives and research questions. This was reviewed with the parent project.
- The parent project outlined the vision and goals its partner company A had for this endeavor. The basic premise was that VR competence recognition tasks would be used as supplementary tools during recruitment. Recruitment would be targeted at assisting roles where formal education would not be necessary and advanced language skills in Finnish or Swedish were not compulsory. This was the baseline on which this study started work. The intention was that partner company A could be flexibly consulted during the study, but the coronavirus outbreak thwarted those plans when the company representatives were swamped with extra work.
- A first draft of ideas of care-related competences and what existing learning taxonomy they could be seen to represent, and at what level. This was done based on the previous research on care competences and training and job admission requirements.
    - This resulted in a detailed matrix containing 37 competences, and it was decided there was a need for simplifying.
- A second, more high-level version of care-related competences. This included nine competences. It was reviewed with the parent project, and four competences were selected for more detailed work.
- A third version was drafted, including the selected four core competences for care.

- Further research on existing learning taxonomies and the basics of VR to understand how it could help in the implementation of the competence recognition tasks.
- Based on the learnings so far, the first drafts of the VR Fast Track competence recognition framework and the competence recognition use cases for VR were made. These were reviewed with the parent project, including a VR specialist.
- To better define and understand the target group and their needs in terms of the VR competence recognition tasks, representatives of an immigration organization were interviewed.
- Iterations of the competence recognition framework and the VR use cases were made.
- Based on the learnings so far and the parent project's needs and resources, it was decided to only focus on one use case, "Spot the problem". The intention was to finalize it so that it could be passed on to implementation. More complex use cases would not be developed further.
- Iterations of the competence recognition framework and the VR use cases were made, including a use case template and a new synthesized version of existing learning taxonomies.
- An interview with partner company B was organized by the parent project, since partner company A had not had the time to collaborate with the project as had been expected. However, the interview did not provide sufficient input in terms of understanding company B's vision of the targeted job role or their competence requirements for job seekers. This was likely because company B did not yet have a clear vision of how what they required fitted with what the VR Fast Track project offered, or perhaps the interviewees were not the "right ones" to consider these questions. Moreover, partner company B's vision was different to that of partner company A, based on which this thesis study had been proceeding so far. It appeared that company B had more interest in using VR for on-the-job training, not recruitment, and that they were hoping to find more formally qualified employees with more advanced language skills. At this point this study could not reasonably be reoriented to that degree, so the decision was made with the parent project to continue along the previously agreed path.
- Iterations of the VR use cases were made, including a choice of two style: a more traditional user-system-flow template and one based on a movie script style. It was thought that the script style could be functional in providing the narrative focus that is important in captivating VR experiences. These were reviewed with the parent project, including a VR specialist. They were also reviewed by the representatives of Krea, a creative agency collaborating with the project.
    - The outcome was that the traditional use case format was preferred, and the script style was not developed further. A narrative script will be developed later by experts at Krea.

    - The parent project and the consulted VR specialist approved the use case template and the current version of the "Spot the problem" use case.
- A proposal for the general competence recognition framework was completed and reviewed by the parent project. It was approved as is. It was agreed that a care-industry specific version of the framework, including concrete examples of competences, would add value for the parent project. Iterative work thus began on it.
- During the study, the parent project expressed wishes to obtain estimates for the relative cost of different VR implementation scenarios. Within the confines of this thesis, it was not possible to give such generalized estimates of VR implementation costs because use cases and other associated circumstances differ so vastly. The matter was also discussed with the parent project's VR specialist, who agreed that giving even heuristic, relative cost estimates for different implementation scenarios is exceedingly difficult.
- A workshop was held with representatives of Krea to review the current outputs of this study and to understand whether they would meet their needs for further development. All the outputs were approved, but Krea also requested an "executive summary" briefing of the project and all its outputs, including working documents.
- After summer holidays, the Krea briefing was created (in Finnish, as requested) and validated with the parent project before being submitted to Krea representatives. The authors of this study also reviewed Krea's own ideas concerning future steps. It was agreed that the parent project would handle the Krea collaboration in the future.
- The care-specific application of the competence recognition framework was reviewed in an interview with representatives of partner company. Specifically, the focus was on reviewing the current proposals for core competences in the field that should be assessed in the VR tasks, and how they should be positioned in the framework. Scheduling the interview was challenging, but its realization was necessary for validating the care-specific thesis outputs. The interviewees provided highly useful comments and agreed to also review an improved version of the care-specific framework. This subsequent iteration was done via email.