Methodologies and Use Cases on Extended Reality for Training and Education

Anacleto Correia
Naval Academy, Portugal

Vitor Viegas
Naval Academy, Portugal

A volume in the Advances in Educational Technologies and Instructional Design (AETID) Book Series

IGI Global
PUBLISHER of TIMELY KNOWLEDGE

Published in the United States of America by
IGI Global
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA, USA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Library of Congress Cataloging-in-Publication Data

Names: Viegas, Vitor, 1976- editor. | Correia, Anacleto, 1961- editor.
Title: Methodologies and use cases on extended reality for training and education / Vitor Viegas and Anacleto Correia, editors.
Description: Hershey, PA : Information Science Reference, 2022. | Includes bibliographical references and index. | Summary: "The objective of this book is to describe, for the domain of education and training, the current research status of extended reality usage, discuss the foreseen advancements in the design and development of various types of immersive learning environments, as well as the emerging pedagogical innovations in the field"-- Provided by publisher.
Identifiers: LCCN 2022021396 (print) | LCCN 2022021397 (ebook) | ISBN 9781668433980 (hardcover) | ISBN 9781668433997 (paperback) | ISBN 9781668434000 (ebook)
Subjects: LCSH: Virtual reality in education. | Artificial intelligence--Educational applications.
Classification: LCC LB1044.87 .M48 2022 (print) | LCC LB1044.87 (ebook) | DDC 371.33/468--dc23/eng/20220623
LC record available at https://lccn.loc.gov/2022021396
LC ebook record available at https://lccn.loc.gov/2022021397

This book is published in the IGI Global book series Advances in Educational Technologies and Instructional Design (AETID) (ISSN: 2326-8905; eISSN: 2326-8913)

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material.
The views expressed in this book are those of the authors, but not necessarily of the publisher.

For electronic access to this publication, please contact: eresources@igi-global.com.

Advances in Educational Technologies and Instructional Design (AETID) Book Series

ISSN:2326-8905
EISSN:2326-8913

Editor-in-Chief: Lawrence A. Tomei Robert Morris University, USA

MISSION

Education has undergone, and continues to undergo, immense changes in the way it is enacted and distributed to both child and adult learners. In modern education, the traditional classroom learning experience has evolved to include technological resources and to provide online classroom opportunities to students of all ages regardless of their geographical locations. From distance education, Massive-Open-Online-Courses (MOOCs), and electronic tablets in the classroom, technology is now an integral part of learning and is also affecting the way educators communicate information to students.

The **Advances in Educational Technologies & Instructional Design (AETID) Book Series** explores new research and theories for facilitating learning and improving educational performance utilizing technological processes and resources. The series examines technologies that can be integrated into K-12 classrooms to improve skills and learning abilities in all subjects including STEM education and language learning. Additionally, it studies the emergence of fully online classrooms for young and adult learners alike, and the communication and accountability challenges that can arise. Trending topics that are covered include adaptive learning, game-based learning, virtual school environments, and social media effects. School administrators, educators, academicians, researchers, and students will find this series to be an excellent resource for the effective design and implementation of learning technologies in their classes.

COVERAGE

- Web 2.0 and Education
- Social Media Effects on Education
- Instructional Design Models
- Adaptive Learning
- K-12 Educational Technologies
- Curriculum Development
- Collaboration Tools
- Higher Education Technologies
- Online Media in Classrooms
- Game-Based Learning

IGI Global is currently accepting manuscripts for publication within this series. To submit a proposal for a volume in this series, please contact our Acquisition Editors at Acquisitions@igi-global.com or visit: http://www.igi-global.com/publish/.

The Advances in Educational Technologies and Instructional Design (AETID) Book Series (ISSN 2326-8905) is published by IGI Global, 701 E. Chocolate Avenue, Hershey, PA 17033-1240, USA, www.igi-global.com. This series is composed of titles available for purchase individually; each title is edited to be contextually exclusive from any other title within the series. For pricing and ordering information please visit http://www.igi-global.com/book-series/advances-educational-technologies-instructional-design/73678. Postmaster: Send all address changes to above address.

Titles in this Series

For a list of additional titles in this series, please visit:
http://www.igi-global.com/book-series/advances-educational-technologies-instructional-design/73678

Guide to Integrating Problem-Based Learning Programs in Higher Education Classrooms Design, Implementation, and Evaluation
Pam Epler (Youngstown State University, USA) and Jodee Jacobs (Youngstown State University, USA)
Information Science Reference • © 2022 • 246pp • H/C (ISBN: 9781799881773) • US $205.00

EdTech Economy and the Transformation of Education
Sara Fazzin (Xenophon College London, UK)
Information Science Reference • © 2022 • 294pp • H/C (ISBN: 9781799889045) • US $215.00

English as a Foreign Language in a New-Found Post-Pandemic World
Walaa M. El-Henawy (Port Said University, Egypt) and Maria del Mar Suárez (Universitat de Barcelona, Spain)
Information Science Reference • © 2022 • 335pp • H/C (ISBN: 9781668442050) • US $215.00

Handbook of Research on Learner-Centered Approaches to Teaching in an Age of Transformational Change
Billi L. Bromer (Brenau University, USA) and Caroline M. Crawford (University of Houston-Clear Lake, USA)
Information Science Reference • © 2022 • 385pp • H/C (ISBN: 9781668442401) • US $270.00

Handbook of Research on Teacher and Student Perspectives on the Digital Turn in Education
Sviatlana Karpava (University of Cyprus, Cyprus)
Information Science Reference • © 2022 • 586pp • H/C (ISBN: 9781668444467) • US $270.00

For an entire list of titles in this series, please visit:
http://www.igi-global.com/book-series/advances-educational-technologies-instructional-design/73678

IGI Global
PUBLISHER of TIMELY KNOWLEDGE

701 East Chocolate Avenue, Hershey, PA 17033, USA
Tel: 717-533-8845 x100 • Fax: 717-533-8661
E-Mail: cust@igi-global.com • www.igi-global.com

Table of Contents

Chapter 6
Case Experiences With Immigrants on Workforce Training Using Virtual Reality

Raine Kauppinen
https://orcid.org/0000-0002-6420-4091
Haaga-Helia University of Applied Sciences, Finland

Merja Drake
https://orcid.org/0000-0003-1929-630X
Haaga-Helia University of Applied Sciences, Finland

ABSTRACT

Due to the rapid changes in the labor market, people need to constantly reshape their competencies, resulting in a tremendous need to reskill the workforce. Vocational training has traditionally been the task of educational institutions; however, today some companies also perform their own training. Overall success in establishing an individual's career depends on successful entry into the workforce, and in case of immigrants, entering the workforce is even more demanding. The key question is how educational institutions and companies can cooperate in this area. Immersive environments like virtual reality offer one type of solution. They are increasingly being used in workforce training and changing landscapes in educational institutions and companies. Using case examples, this chapter illustrates how several companies have jointly developed vocational materials with educational institutions and immigrants. The experiences are discussed, and examples of virtual reality training tasks implemented and connecting them to relevant competencies are presented.

DOI: 10.4018/978-1-6684-3398-0.ch006

INTRODUCTION

Nowadays, with the rapidly changing labor market and careers, people need to constantly to reshape their skills and competencies. The World Economy Forum (World Economy Forum, 2020) has calculated that new technology will be transforming over one billion jobs worldwide in the next decade, and there is a tremendous need to reskill the workforce. Traditionally, educational institutions were mainly responsible for conducting vocational training of the workforce. Currently, to a greater degree than before, companies such as Google, Apple, Hilton, and especially start-ups are training their own workforce. Thus, what is the role of higher education in the future? How could companies and educational institutions work in cooperation to reskill and train the workforce using emerging technologies?

Success in establishing an individual career depends on successful entry into the workforce after completing compulsory education. However, the direct transition from compulsory education into initial on-the-job training and to the workforce has become more difficult than ever before. In the case of immigrants, this is even more demanding (Eronen et al., 2014; OECD, 2018); for example, this is because of the diverse background of the immigrants. Although they often possess the skills and the competencies needed to be a part of the workforce, it is often difficult to recognize them due to the lack of formal degrees or diplomas.

New technologies and immersive learning environments such as extended reality (XR) including virtual reality (VR) may offer one type of a solution. VR can be particularly useful for training and recognizing the competencies of immigrants because instructions and the training material need not necessarily be only linguistic. Instead, training can be produced so that the correct modes of action are first demonstrated before being practiced. In addition, exercises can be safely repeated, and knowledge can be verified on a virtual world. The largest obstacles to using VR have been the cost and the required resources (Kavanagh et al., 2017). Decreasing the software and equipment costs may make more experiments possible, while some challenges might occur due to the rapidly changing technology (McGrath et al., 2018).

Thus, VR is one of the emerging technologies that is changing the training landscapes both in companies and in educational institutions. However, despite VR's potential, its full potential in workforce education and the process in which collaborating educational institutions and companies design, develop, and create VR-based training materials with the potential employees have not yet been researched to an adequate extent. This chapter, using case examples, discusses how educational institutions and companies in the health care, hospitality, and cleaning services have jointly and collaboratively developed, produced, and tested vocational training materials created using VR technology with immigrants.

The objective of this chapter is to help understand the potential of VR as a tool for vocational training, illustrate the potential with examples of the general types of VR training tasks that can be implemented, and present a model for connecting the necessary competencies to VR implementations used in training to evaluate learning and recognize competence. In addition, the experiences from the viewpoints of the educational institutions, companies, and immigrants are explored to provide insights on the feasibility of the approach. Based on the work done and on the experiences gained, future research directions are also discussed.

BACKGROUND

VR is increasingly being used in delivering learning and training material. VR has been particularly relevant in fields such as medicine, engineering, aviation, and safety training with suggested benefits of interaction, immersion, deep concentration, and real-life experiences (Dalgarno et al., 2002; Kulik et al., 2017; Melo et al., 2019; Wallach et al., 2011). Training situations can be either individual or collaborative, and participants learn by actively participating in the learning situation. The learning situation is an immersive experience without external distractions, and it can enhance interpersonal communication. VR also supports different types of learning styles.

Regarding immigrants, authors have previously performed research focusing on how to find how to recognize immigrants' competencies using VR to reduce language-related barriers to immigrants' employability (Drake, 2019; Kauppinen et al., 2021; Kauppinen & Drake, 2020b, 2020a). Based on this, it is important to understand how immigrants can participate in workforce training and what the role of educational institution is to foster personal growth and active citizenship of the immigrants. Furthermore, because the companies in different fields are the employers, a joint and collaborative effort is essential to provide usable training materials focusing on the relevant competencies.

As used in this chapter, competence is a combination of knowledge, skills, attitudes, and abilities required in the workplace and is a measure of skills and proven knowledge (Kauppinen et al., 2021). To develop and recognize competencies, the general approach is to use a learning taxonomy such as Bloom's original (Bloom et al., 1956) that has since been revised (Anderson et al., 2001). An alternative to Bloom's taxonomy, designed as a tool for practitioners and providing a more research-based alternative, is Marzano's new taxonomy (Marzano & Kendall, 2007) which focuses on cognitive abilities comprising three main systems: the self-system, the metacognitive system, and the cognitive system. These taxonomies are hierarchical systems in which one must master lower levels before proceeding to higher levels. In addition to hierarchical taxonomies, there are non-hierarchical taxonomies that broaden the understanding of the competences that are relevant for learning (Fink, 2003; Wiggins & McTighe, 2006) by highlighting the aspects of learning that are difficult to measure.

Using VR's potential as a tool for vocational training and creating usable training material requires associating the learning modeled by learning taxonomies and concrete competencies related to the specific job descriptions of companies. This can be achieved by joint collaboration. For example, universities of applied sciences in Finland mainly focus on conducting applied research because they cooperate closely with companies and different stakeholders in the region and innovate new services and products in cooperation. There are several relevant approaches to applied research in terms of the use of VR in workforce training, for example, research and innovation ecosystems and living labs.

Recently, the number of discussions on how to define research and innovation ecosystems and their meaning has been increasing. The importance of ecosystem in the field of the management of technology and innovation has been emphasized (Tsujimoto et al., 2018). Notably, the range of ecosystem concepts and definitions used is broad, and five different types of ecosystems have been identified: digital, complementary, supplier, business group, and global professional human network ecosystems. An ecosystem can be defined to be a historically self-organized or managerially designed multilayer social network. It consists of actors that have different attributes, decision principles, and beliefs. Furthermore, an ecosystem exits to provide a product, a service, or a system. (Tsujimoto et al., 2018).

An ecosystem brings competition value for the participating companies (Clarysse et al., 2014). When focusing on defining universities' research ecosystems (Pandey & Pattnaik, 2015), two different viewpoints can be identified: the stakeholder viewpoint and the process viewpoint. However, the innovation ecosystem is claimed to be the all-too-often ambiguously utilized concept across academia (Ritala & Almpanopoulou, 2017). Furthermore, it is stressed that appending "eco-" to "innovation systems" adds nothing of substance, that an innovation ecosystem is actually a faulty analogy of natural ecosystems, and that it leads to cognitive dissonance and potentially also to harmful policy choices (Oh et al., 2016).

The core concept of the living labs is to create novel products and new services, produce prototypes, and test prototypes with the help of a network. A living lab can be viewed from two viewpoints. First, it can be viewed as a platform which can be owned, for example, by a city, a company, or an educational institution and has a large external developer network. Second, it can be viewed as participation emphasizing the aims, activities such as development, co-creation, and iteration in the context of the living lab (Leminen et al., 2017; Pallot et al., 2011; Steen & van Bueren, 2017). As with the ecosystem, the key function of living labs is to add value for the participants.

Both the living lab and the ecosystem concept also include an idea of expanding the innovation and research network for non-business actors such as citizens, associations, and end-users. Similar to the five types of ecosystems mentioned earlier, five types of living labs have been defined (Ståhlbröst & Holst, 2021). These include research living labs that focus on the innovation process, corporate living labs that focus on innovations co-created with stakeholders, organizational living labs that focus on innovations of organization members, intermediary living labs that focus on various stakeholders innovating in the cooperation in a neutral area, and time-limited living labs that focus on a specific project and will close when the project ends. Living labs are useful in changing end-users roles from passive consumers to active prosumers and in innovating and involving citizens in developing solutions for everyday problems with educational institutions, companies, and other stakeholders (Ståhlbröst & Holst, 2021).

WORKFORCE TRAINING USING VR

Although VR is already being used in companies and education, there are several aspects in which its potential is not yet fully applied. First, VR could be more beneficial in tackling the challenge of the declining workforce and employing immigrants because it provides a safe and fast way of testing and training potential employees. Second, the current vocational virtual learning environments focus on certain fields, mainly excluding, for example, the service sector which provides an array of entry-level positions and possibilities for on-the-job training. Finally, workforce training and recognizing competencies could be more clearly connected to concrete tasks—implementable also in VR—in the workplace to the levels of a learning taxonomy providing good basis for evaluating competence and learning.

Declining Workforce and Employment of Immigrants

Especially young peoples´ success in establishing their individual career paths depends on successful entry into the workforce once they have completed their compulsory education. However, at the same time, it has become difficult to make a direct transition from compulsory education into initial on-the-job training and into the workforce. If young people stay outside education and outside working life, it has negative effects, which will last for around 5 to 7 years (Åslund & Rooth, 2007).

In case of immigrants or people of foreign background, making their own career path is even more demanding. For example, four of five immigrants living in Finland are of working age. However, the employment rate of working-age immigrants is considerably lower than that of the general population: 51.1% of people from foreign backgrounds aged 20 to 64 and 71.0% of people from Finnish backgrounds were employed. The difference between groups in the proportion of employed people in the total population was 19.9 percentage points (Pasila & Sutela, 2019; Statistics Finland, 2021).

One challenge is that the educational and professional backgrounds of immigrants and of people of foreign backgrounds are very diverse—from lawyers and professors to basic or even no formal education. According to a study conducted in 2019, 7% respondents were without an undergraduate degree and 23% were mere undergraduate graduates, while there were 25% secondary graduates and 45% tertiary graduates (Witting, 2019). Many of the immigrants also face language challenges. However, it is worth noticing that some of the immigrants speak better Finnish than English.

Nevertheless, immigrants are predicted to play a key role in maintaining an adequate level of the working-age population (OECD, 2018). This means that the existing competencies of immigrants need to be recognized and feasible ways of learning, such as multisensory and immersive materials and environments, need to be developed. Creating such environments jointly between educational institutions, employing companies, and immigrants is one solution to this problem, and a living-lab–based way of achieving it is discussed later in this chapter.

VR and Virtual Learning Environments

As stated earlier in this chapter, while VR has been employed as a learning environment, its use has been focused on certain fields such as engineering, aviation, and safety training. In other words, VR in learning is currently applied mainly in industrial environments and not so much, for example, in the service sector. Some applications in the service field do exist, such as completing different work stages (Nirhamo, 2019) in restaurant work. VR has also been applied to some extent in hospitality (Torrico et al., 2020) and tourism (Kim et al., 2020); however, it has broad application prospects in vocational learning in the service sector.

In the health care sector, especially medicine, VR has been used more extensively, for example, in assessing the food-related emotional responses of patients with eating disorders (Gorini et al., 2010) and in psychotherapy as an alternative to exposure (Wallach et al., 2011). Recently, VR has been used to assess the competence of emergency medicine students (McGrath et al., 2018). However, even in the more extensively covered fields, virtual learning environments rarely have a direct connection with the related curriculum and evaluation of learning.

However, an example on how this can be done has been illustrated. In the 90s, the training potential of VR in laparoscopy was identified (Ota et al., 1995), and the model was later further improved, providing evidence-based curriculum for laparoscopy students. The related tasks can be divided into three levels of difficulty:

easy, medium, and difficult (Aggarwal et al., 2006). The laparoscopy curriculum was developed even further when descriptions of three types of surgical skills measured (safety, technical skill, and dexterity) were created as tasks that were implemented in VR (Loukas et al., 2011).

The example in laparoscopy can and should be followed in other VR applications and virtual learning environments because it ties the implementation and the environment to the curricula. Furthermore, it helps in the evaluation of learning, workforce training in companies, as well as in competence recognition overall, as discussed next. In addition, later in this chapter, several VR learning environments for the service sector are presented as examples.

Workforce Training and Competence Recognition

Companies have a practical approach to workforce training, and, understandably, they are interested in having employees trained specifically for their environments. However, educational institutions providing formal degrees and related education aim to prepare their learners to be part of a workforce and to be able to work in any organization in a field. Work has been done in combining these viewpoints, for example European Skills, Competencies, and Occupations combines specific work roles and the necessary competencies and has input both from the educational institutions and from companies (European Commission, 2019).

From the viewpoint of recognizing competence and evaluating learning, the domains or basic types of educational objectives are well known in educational institutions and are taken from selected taxonomy such as Bloom's original (Bloom et al., 1956), mentioned earlier in this chapter. Typically, educational objectives are divided into three types: cognitive objectives involving mental processes such as memory recall and analysis; affective objectives involving interest, attitudes, and values; and psychomotor objectives involving motor skills.

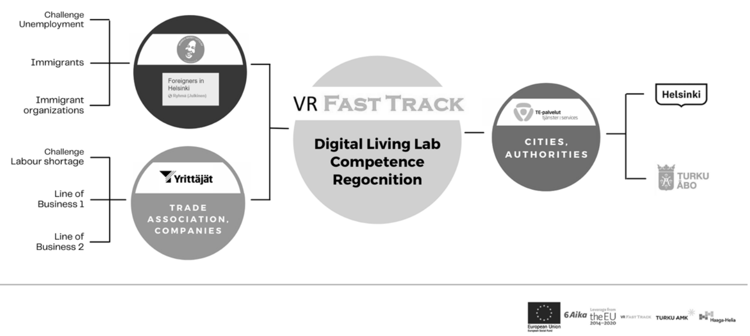
Furthermore, motivation is the primary factor that determines whether a learner will complete a learning-related task and is highly predictive of engagement. In turn, engagement is a strong predictor of retention. More often, motivation and engagement are emphasized better in the non-hierarchical taxonomies (such as (Fink, 2003; Marzano & Kendall, 2007); however, they are less applied in educational institutions than the traditional hierarchical ones.

Because the taxonomy of learning objectives is a framework for classifying statements of what is expected or intended to be learned based on instructions, companies in a specific field are indeed a good source of the objectives. However, despite the work done, a gap exists in vocational workforce training between companies and educational institutions. In addition to the joint cooperation, this gap can be closed by having a method to explicitly connect the learning objectives of a relevant competence to a learning taxonomy and also to the related task where the competence is applied in the workplace. Later in this chapter, we present a model for this to provide a basis for evaluating the competence and learning usable for both companies and educational institutions. Notably, it uses tasks that can be implemented in VR.

SOLUTIONS AND RECOMMENDATIONS

The solutions and recommendations presented here are based on the work and results on a project called VR Fast Track, in which the issues related to vocational learning and workforce training were addressed by applying VR and working in collaboration with the relevant stakeholders. The solution for the joint collaboration in the project has characteristics of both a research and innovation ecosystem and a living lab. However, it is closest to an intermediary living lab because active involvement from different stakeholders is required in the different stages of the project which include ideation, planning, implementation, and evaluation. The stakeholders form a living lab network shown in Figure 1.

Figure 1. Living lab network of the VR Fast Track Project.



The stakeholders included immigrants and immigrant organizations (upper left in Figure 1), companies and related associations (lower left in Figure 1), and educational institutions (center in Figure 1) and authorities (right in Figure 1). The challenges were caused by immigrants (unemployment) and companies (labor shortage), whereas educational institutions provided coordination (living lab setting and network) and offered expertise (VR training and learning solutions) and authorities provided support (information and benefits for participating immigrants). The immigrant organizations and associations of companies were used to contact immigrants and companies, respectively, although immigrants and companies were also contacted directly by educational institutions.

VR Solutions for Workforce Training

The case examples of VR solutions presented here are for workforce training for the hospitality, health care, and cleaning sectors (see also Drake & Kauppinen, 2021). They were developed in the living lab network in Figure 1. The stakeholders involved are detailed in Table 1. The case examples are chosen from hospitality, health care, and cleaning services because these lines of business offer entry-level positions suitable for immigrants with low or no formal education and who face challenges in language skills. Furthermore, these lines of businesses suffer from labor shortage in Finland, while at the same time, the Finnish society as a whole is facing the challenge of inadequate employment of immigrants.

The number of immigrants involved in the case examples is over 100. They are from the cities of Helsinki and Turku and have been involved in groups from a couple of immigrants to around 20 at a time. Small groups have made it possible to achieve in-depth participation from each individual.

As seen in Table 1, four immigrant organizations, six companies, one association of companies, three educational institutions, and the authorities in two cities were also involved. The authorities were represented by skill centers and unemployment offices. Although the example cases and their stakeholders were from Finland and the target group of employees was immigrants, similar VR solutions can be applied in other countries and lines of business as well as for other relevant stakeholder and target groups. For this, general VR task types appearing in the solutions are summarized after the case examples.

Hospitality Case Example

The hospitality case example domain is restaurant work (see also Kauppinen et al., 2021). It is related to hygiene competence, which is an essential competence, since there are mandatory requirements that all employees working with food products must follow. Therefore, it is considered an important competence by the employers represented by the two restaurant company representatives as well as experts in restaurant work education, i.e., the vocational teachers from Stadin AO educational institution.

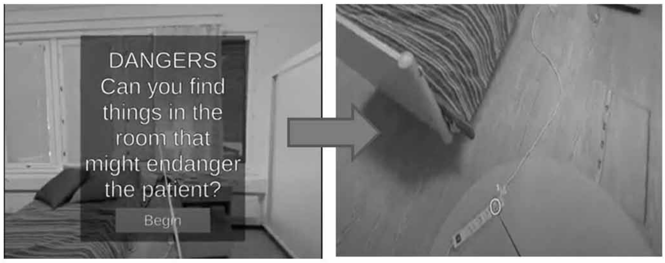
The VR solution for the restaurant work involves answering true or false questions presented in a multisensory manner (combination of text, voice, and visual) in the VR restaurant environment by pointing to the right answers. It is implemented

Table 1. Stakeholders of the case examples.

Case Example	Immigrants and Organizations	Companies and Associations	Educational Institutions	Authorities
Hospitality	• Immigrants interested and training in restaurant work (Helsinki) • African Care (Helsinki) • Finnish Refugees Council (Helsinki) • Association of Thai Women Network in Finland Council (Helsinki)	• One regional restaurant company (Helsinki) • One national restaurant company • Trade association (Helsinki)	• Haaga-Helia University of Applied Sciences (Helsinki) • Stadin AO (Helsinki)	• City of Helsinki (Skill center)
Health care	• Immigrants interested in health care (Turku) • Daisy Ladies (Turku)	• Two national health care companies	• Haaga-Helia University of Applied Sciences (Helsinki) • Turku University of Applied Sciences	• City of Turku (Skill center, unemployment office)
Cleaning service	• Immigrants interested and training in cleaning services (Helsinki and Turku) • Daisy Ladies (Turku)	• Two regional cleaning service company (Helsinki and Turku)	• Haaga-Helia University of Applied Sciences (Helsinki) • Turku University of Applied Sciences • Stadin AO (Helsinki)	• City of Helsinki (Skill center) • City of Turku (Skill center, unemployment office)

Figure 2. The VR solution for hospitality.

Figure 3. The assisted living VR solution for health care.



using the Unity game engine (Unity, n.d.) and illustrated in Figure 2 (a video is also available, see VR Fast Track Project, 2021b).

Finnish or English can be selected as the language, and there is a time limit for answering the questions. After the questions, the number of correct answers is shown. The questions are the similar to those in the official hygiene certificate test (Finnish Food Authority, 2020), which is administered as a pen-and-paper test under a controlled environment. A certificate is required for anyone working with food products; thus, the solution is used in learning about hygiene and in preparing the immigrants for official tests.

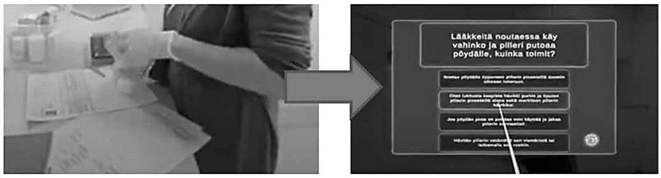
Based on the information obtained from using the VR solution and from the results of the official test, it can be said that the results correlate very well. This means that the solution can be used to both recognize the hygiene competence of an individual and, for example, if used before and after teaching hygiene, also to evaluate learning. For companies, this is a good way to evaluate if a person can be sent directly to the official certificate test or if additional training provided by the company or an educational institution is required.

Based on the feedback from immigrants, the immersion of the solution is surprisingly strong, even though the restaurant environment is cartoonlike. Immersion makes it possible to focus on answering the questions even under noisy environments. However, the disadvantage is that due to the strong immersion, some of the users experience symptoms similar to motion sickness.

Health Care Case Example

The health care case example is twofold because there were two national companies in the living lab network. Separate VR solutions were prepared with both companies; however, the same VR solution base could be used because the platform was implemented by educational institution. For one company, an assisted living related

Figure 4. VR solution for dispensing medication for health care.



VR solution was developed. It is illustrated in Figure 3 (a video is also available, see VR Fast Track Project, 2021a).

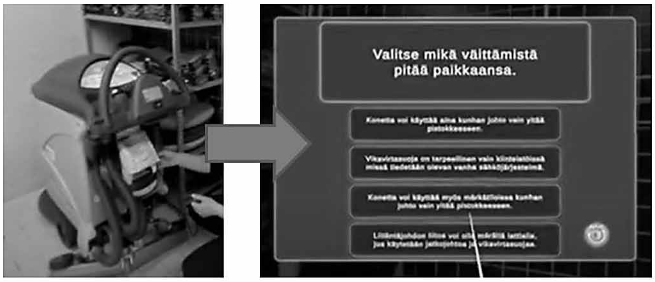
In the assisted living VR solution, the goal is to look around of an apartment of an elderly person in an assisted living facility and point out indicators of areas related to the state of the person as well as the quality of living. Looking around can be done freely and pointing the correct items or similar features in the apartment can be done in a free order, although the solution is divided into the sections that are done one by one with different indicators to be identified.

Finnish or English can be selected as the language, and after all the sections, the number of correct answers by sections is shown. The indicators to be spotted can be positive or negative; however, the number of indicators to be found can be shown. Nevertheless, the solution is a bit more difficult than one would think at a glance, for example, because no additional information is given of the asked indicators. For example, in Figure 3, the section is about things that can endanger the patient, but no examples are given. Furthermore, the goal is shown only at the beginning of the section; thus, it must be remembered throughout the section.

This solution follows a checklist of the company on what things an employee visiting a person in an assisted living facility should focus on; thus, it serves both as training material as well as a way to recognize and evaluate competence in following practices in assisted living related work. Although it is done based on information obtained from one company, it is usable in similar companies and, for example, in training provided by an educational institution as well.

For other companies, a VR solution for medication dispersion was developed. It is illustrated in Figure 4 (a video is also available, see VR Fast Track Project, 2021d). In this solution, the goal is to answer multiple choice questions related to dispensing medication. Here, a video showing the correct procedure is provided so that the video advances for some time, after which a related question is asked. If the answer is incorrect, another choice can be selected. The feedback is immediate, and the video advances either after the correct answer is given or after two incorrect answers. At the end, when all of the video has been shown and all the questions have been answered, the breakdown of the results is shown.

Figure 5. The cleaning machine maintenance VR solution for cleaning services.



In this solution, currently only Finnish is available as a language. There is sound in the video; however, there is no talking, and the questions are not read out aloud. This means that the solutions are not as multisensory as the hospitality case example. For the company, this has not yet been an issue because they are planning to use the solution in on-the-job training for new employees and as a recap material for more experienced employees. This means that the users of the solution are, at least at first, already familiar with the procedure of dispensing medication. However, notably, dispensing medication is a critical task because there is no margin for error. As with the assisted living solution, although this solution is provided based on one company's input, it is usable in similar settings and in educational institutions. However, for better feasibility, English language and multisensory support should be added.

Both solutions are developed using 3DVista (3dVista, n.d.) and 360° videos; thus, they require less modeling than the hospitality solutions. However, they require physical real-life locations and real people. The solutions also illustrate an advancement of the living lab network because the same base could be used to develop solutions for different companies.

Cleaning Service Case Example

The VR solution for cleaning services involves the maintenance of a cleaning machine. It is illustrated in Figure 5 (a video is also available, see VR Fast Track Project, 2021c). The solution follows the ideas of health care solutions. It also has the same characteristics; thus, currently, only Finnish is available as a language, there is no talking, and the questions are not read aloud. However, because this solution is intended to be used with little or no experience in the maintenance of the cleaning machine, English language and multisensory support should be added.

The lack of narration was also mentioned in the feedback when the solution was tested with immigrants. The feedback contained other development ideas as well. Especially, it was hoped that the solution would include more content than that related to cleaning machines. For example, adding content related to the maintenance of the cleaning carriage as well as other cleaning equipment was suggested.

Table 2. General VR task types based on the case examples.

Task Type	Variations	Case Example
Answering questions	• True or false without video • Multiple choice with video	• Hospitality • Health care and cleaning
Spot the problems	• Free order	• Health care

This solution is used here as a further example of the benefits of the living lab network. In addition to being able to use the technical base of the VR solution in different cases, the living lab network could also use the same ideas over different lines of business. This shows that the task types are independent from the content such as learning objective or competence and can be seen as general VR task types applicable to multiple settings.

General VR Task Types

Based on the case examples, two basic types of general VR task types can be identified: answering questions and spotting problems. These have several variations. The questions can be true or false or multiple-choice questions, and they may include videos. Spotting the problems can be free or in a fixed order (although only free variation is included in the case examples). The general task types and their variations are summarized in Table 2.

Notably, these are not the only general VR task types but the ones that can be derived from the case examples. The general task types are useful, for example, in planning new VR solutions in the existing or new business areas. However, for feasible evaluation and recognition of competence, they need to be explicitly associated with the level in the taxonomy, the learning objectives, and the competences.

Evaluating and Recognizing Competence With VR

Evaluating and recognizing competence with VR requires identifying the relevant competences and learning objectivities with their level in the learning taxonomy and connecting them. Competencies have several levels and different levels have different learning objectivities. To reach a level of competence, the related learning objectives need to be met. The learning objectives for different levels also need to have concrete VR tasks that are used to evaluate whether the level has been reached. Next, these areas are explored using an example of hygiene competence from the previous hospitality case example (see also Kauppinen et al., 2021). After that, a model for competence recognition and evaluation constructed based on the case examples is presented.

Identifying Relevant Competencies

For workforce training, as illustrated by the case examples, the input for the relevant competencies is taken from companies. However, as also seen in the case examples, some of them may be required by authorities. Educational institutions also have the related expertise because they maintain curricula for vocational education. However, for example, the priorities of competencies may rapidly change and from company to company; thus, in the regional sense, local and locally operating national companies are a valuable source of the current and relevant competencies.

In this example, hygiene competence in restaurant work is used. This is because it is currently essential according to the companies in the living lab network and because it is also required by the food authorities. However, hygiene is an important topic as competencies in general; thus, the related learning objectives must be defined to be able to evaluate and recognize it.

Connecting Competencies and Learning Objectives

The learning objectives are statements of concrete things that a person must be able to do. These are often skills that are applied as part of the work; however, they can also be something that can be handled mentally, verbally, or in writing and relate to knowledge. Again, especially for the objectives that are part of the everyday practical work, companies of the line of business in question are a valuable source for the learning objectives. However, educational institutions are traditionally especially good in defining knowledge based on the learning objectives.

In this example, for the hygiene competence, a learning objective related to knowledge is what is required for passing the hygiene certificate test, namely being able to answer questions regarding hygiene based on the available guidelines and information. This corresponds to the hospitality case example. However, another related learning objective is being able to identify problems (indicators) in hygiene in the workplace. This can be compared to the assisted living solution in the health care case example.

Table 3. Hygiene in restaurant work as an example of evaluating and recognizing competence.

Competence	Learning Objectives	Taxonomy Levels	VR Task
Hygiene (Restaurant work)	• Spot the problems in hygiene in the workplace	• Knowledge	• Spot the problems in free order
	• Answer questions related to hygiene	• Comprehension	• Answer true / false questions, no video

Connecting Learning Objectives, Taxonomy Levels and VR Tasks

Different learning objectives and VR tasks match different levels in the learning taxonomy. Mapping these objectives requires the selection of a learning taxonomy used and based on its levels and analyzing the learning objectives and the VR tasks against it. Although some companies may have expertise in this, this is typically the key area of expertise for educational institutions.

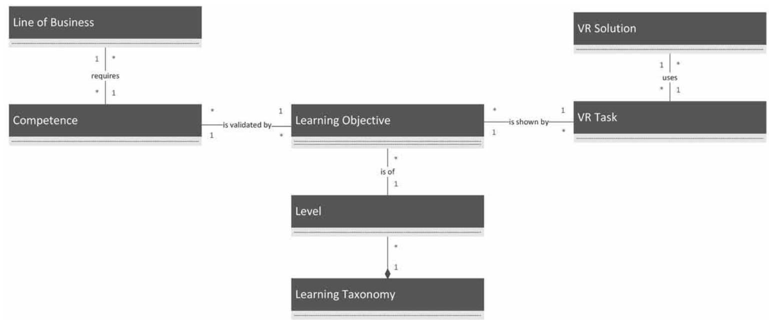
In the example, Bloom's original taxonomy's (Bloom et al., 1956) cognitive part is applied. It has six levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. Of the learning objectives defined, identifying problems (assuming they are straightforward) would be on the knowledge level and answering (often quite tricky) questions in the hygiene certification test would be on the comprehension level, as shown in Table 3.

In Table 3, suitable VR tasks have also been selected and associated with the learning objectives via taxonomy levels. Here, VR tasks are of general VR task types identified earlier (see Table 2). However, if there is no suitable existing VR task type, one should be designed. As can be seen, the example is partial and its full version would have the remaining four taxonomy levels, related learning objectives, and VR tasks. Based on the experiences gained from the living lab network, effort should focus on VR should be in the first two or three levels because they seem to provide good benefits, and the complexity of VR tasks and their implementation is likely to rise in the higher levels. Rising complexity also means the rise of necessary resources such as time spent in implementation; after the third level, the use of effort may overweigh the benefits.

A Model for Competence Recognition and Evaluation

Based on previous discussions and the work done in the living lab network, the model shown in Figure 6 can be presented for competence recognition and evaluation. The model shows the relationships between lines of businesses, competencies, learning objectives, taxonomy levels, learning taxonomies, VR tasks, and VR solutions. The

Figure 6. A model for competence recognition and evaluation.



notation of the model follows the class diagram of UML (unified modeling language) (Object Management Group, 2021).

According to the model, a line of business requires several competencies, and the same competence may be required by several lines of businesses. A competence is validated by several learning objectives, and the same learning objectives can be used while validating several competencies. Each learning objective is of one level in a learning taxonomy, and the same level may be used for several learning objectives. Each learning taxonomy consists of several levels; however, the individual level is always a part of one taxonomy. Learning objectives are shown by several VR tasks, and one VR task can be used to show several learning objectives. Finally, VR solutions use several VR tasks, and the same VR task may be used in several VR solutions.

Notably, the model in Figure 6 is a metamodel. This means that the model has to always be applied (in UML language instantiated) for the specific cases having the actual line of business, competencies, learning objectives, learning taxonomy with its levels, VR tasks, and VR solution. The application of the model is similar to the result of the example shown in Table 3.

Recommendations

Based on the experiences and solutions, several recommendations for VR-based workforce training with immigrants can be presented. The recommendations are summarized in Table 4, and they are related to joint collaboration, developing VR solutions, and evaluating and recognizing competence with VR. They are applicable to other similar settings and target groups than the one covered in this chapter.

Overall, both joint collaboration, for example, using living lab approach as well as applying VR for workforce training can be recommended. However, to apply VR meaningfully in workforce training, joint collaboration is required

Table 4. Recommendations on VR-based workforce training with immigrants.

Area	Recommendations
Joint collaboration	• Educational institutions should coordinate • Educational institutions should be responsible for the platform • Several regions and companies should be involved
Developing VR solutions	• Iterative approach should be used • Testing should be performed often • Feedback should be collected and evaluated when testing
Evaluating and recognizing competence with VR	• High priority competencies should be identified with companies • Learning objectives should be practical • General VR tasks should be applied

because all stakeholders have important contributions. The recommendations for joint collaboration are about the roles as educational institutions seem to be in the best position to coordinate collaboration and are responsible for the development platform. This is because educational institutions are neutral parties, can facilitate cooperation, and also spread ideas freely via facilitation or platform. Furthermore, the gained experiences show that it is beneficial to have participants from several geographical regions as well as to have several companies involved even from the same lines of businesses.

Regarding the development of VR solutions, an iterative approach is another must. This goes well with the observation on benefits of testing often both with companies and immigrants. This way, valuable input can be obtained early, and VR solutions can be shaped based on that. Furthermore, when testing, feedback should be collected and evaluated in a systematic manner. This way, the trends and repeating issues can be found. Systematic data collection makes it possible to perform qualitative or quantitative research, which is an added benefit for higher education institutions.

Regarding evaluating and recognizing competencies with VR, the companies know the current priorities of competencies and are very good in stating practical learning objectives. Furthermore, even though educational institutions are very good in knowledge-based learning objectives, practicality should be the focus. For the fluent implementation of the VR solution, existing general VR task types should be prioritized because definition, planning, and implementations of new VR tasks is a time-consuming task. Of course, new VR tasks must be developed at times; however, this should always be evaluated thoroughly and only be done when necessary.

FUTURE RESEARCH DIRECTIONS

Overall, VR is still a relatively new technology, and it is likely that its use will increase in the future. However, the focus is moving on XR having other types of virtuality in addition to VR such as augmented reality. The application of XR in workforce training is therefore a viable future research direction.

Of the topics discussed in this chapter, there are several prominent future research directions. First, the living lab approach along with ecosystems is likely to be used more extensively if the future. This is because joint collaborative development will be increasingly important due to the rapid changes in society such as in the labor market. The resulting challenges can be resolved best by using agile and co-operative approaches such as living lab or ecosystems.

Because the examples in this chapter are individual cases, it is natural that they would provide ground for future research. Their content could be expanded further, and there are several development issues and ideas mentioned in the case descriptions. Work on these would make the implemented VR solutions more comprehensive and would improve their quality.

Finally, the presented model for competence recognition and evaluation is an initial one. It should be further studied and improved. The model is proven to be viable because it is applicable throughout the cases presented in this chapter. It also has novelty in explicitly connecting the VR tasks into the learning objectives and via them, to the relevant competencies.

CONCLUSION

In this chapter, workforce training using VR has been discussed and several case examples have been presented. The target group here was immigrants because they have specific challenges associated with entering the workforce, although they are considered an important part of the future workforce. In addition to the case examples, a living lab approach used, and the experiences gained have been covered. Furthermore, a model for competence recognition and evaluation has been presented.

Overall, the full potential of using VR in workforce training is yet to be discovered. In particular, additional efforts should be directed toward cooperation between companies, educational institutions, and end-users such as immigrants in the development of VR-based training content. This position can be justified by the fact that the labor needs of the companies vary, and the employee must have the current competencies suitable for the company. While creating training materials, different viewpoints are required. Professionals from educational institutions are familiar with the learning pedagogy, and the required competences will come from the companies. However, the learning is experienced and can be expressed only by the learner.

ACKNOWLEDGMENT

This research was supported by the European Social Fund.

REFERENCES

Aggarwal, R., Grantcharov, T., Moorthy, K., Hance, J., & Darzi, A. (2006). A competency-based virtual reality training curriculum for the acquisition of laparoscopic psychomotor skill. *American Journal of Surgery*, *191*(1), 128–133. https://doi.org/10.1016/j.amjsurg.2005.10.014

Anderson, L., Peter, K., Airasian, D., Cruikshank, K., Mayer, R., Pintrich, P., Raths, J., & Wittrock, M. (2001). *Taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives*. Addison Wesley Longman.

Åslund, O., & Rooth, D. (2007). Do When and Where Matter? Initial Labour Market Conditions and Immigrant Earnings. *Economic Journal (London)*, *117*(518), 422–448. https://doi.org/10.1111/j.1468-0297.2007.02024.x

Bloom, B., Engelhart, M., Furst, E., Hill, W., & Krathwohl, D. (1956). *Taxonomy of educational objectives. Book 1 Cognitive domain*. Longmans.

Clarysse, B., Wright, M., Bruneel, J., & Mahajan, A. (2014). Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. *Research Policy*, *43*(7), 1164–1176. https://doi.org/10.1016/j.respol.2014.04.014

Dalgarno, B., Hedberg, J., & Harper, B. (2002). The Contribution of 3D Environments To Conceptual Understanding. *19th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE 2002), 1*, 149–158. http://ascilite.org.au/conferences/auckland02/proceedings/papers/051.pdf

Drake, M. (2019). Embedding virtual reality into competence recognition. *16th International Conference on Cognition and Exploratory Learning in Digital Age, CELDA 2019,* 465–467. doi:10.33965/celda2019_201911r064

Drake, M., & Kauppinen, R. (2021). *New Technology - A New Approach to Further Vocational Training?* doi:10.21125/iceri.2021.1811

DVista. (n.d.). *3DVista*. Retrieved November 29, 2021, from https://www.3dvista.com/

Eronen, A., Härmälä, V., Jauhiainen, S., Karikallio, H., Karinen, R., Kosunen, A., Laamanen, J.-P., & Lahtinen, M. (2014). *Maahanmuuttajien työllistyminen : taustatekijät, työnhaku ja työvoimapalvelut* [Labour Market of Immigrants in Finland]. Publications of Ministry of Economic Affairs and Employment. http://linda.linneanet.fi/F/?func=direct&doc_number=006622519&local_base=fin01%5Cnhttp://www.tem.fi/files/38664/TEMjul_6_2014_web_10022014.pdf

European Commission. (2019). *ESCO handbook* (2nd ed.). Directorate-General for Employment, Social Affairs and Inclusion.

Fink, L. D. (2003). *Creating significant learning experiences for EAL learners*. Jossey-Bass.

Finnish Food Authority. (2020). *Hygienie Passport*. https://www.ruokavirasto.fi/en/private-persons/hygiene-passport/

Gorini, A., Griez, E., Petrova, A., & Riva, G. (2010). Assessment of the emotional responses produced by exposure to real food, virtual food and photographs of food in patients affected by eating disorders. *Annals of General Psychiatry*, *9*(30). http://www.annals-general-psychiatry.com/content/9/1/30

Kauppinen, R., & Drake, M. (2020a). Recognizing competencies of immigrants for restaurant work using virtual reality. *ICERI2020 Proceedings*, 2707–2017. doi:10.21125/iceri.2020.0629

Kauppinen, R., & Drake, M. (2020b). Virtual reality in competence recognition for immigrants. *INTED2020 Proceedings, 1*(March), 5578–5582. doi:10.21125/inted.2020.1515

Kauppinen, R., Drake, M., Anttila, K., & Lindgren, E. (2021). Implementing Virtual Reality Based Competence Recognition. *2021 9th International Conference on Information and Education Technology (ICIET)*, 415–422. doi:10.1109/ICIET51873.2021.9419617

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A Systematic Review of Virtual Reality in Education. *Themes in Science and Technology Education*, *10*(2), 85–119.

Kim, M. J., Lee, C. K., & Jung, T. (2020). Exploring Consumer Behavior in Virtual Reality Tourism Using an Extended Stimulus-Organism-Response Model. *Journal of Travel Research*, *59*(1), 69–89. https://doi.org/10.1177/0047287518818915

Kulik, A., Kunert, A., Beck, S., & Fröhlich, B. (2017). Collaborative Virtual Reality for Joint Learning Experiences. *12th International Conference on Computer Supported Collaborative Learning (CSCL 2017)*, 721–722.

Leminen, S., Rajahonka, M., & Westerlund, M. (2017). Towards Third-Generation Living Lab Networks in Cities. *Technology Innovation Management Review, 7*(11), 21–35. doi:10.22215/timreview/1118

Loukas, C., Nikiteas, N., Kanakis, M., & Georgiou, E. (2011). Deconstructing laparoscopic competence in a virtual reality simulation environment. *Surgery*, *149*(6), 750–760. https://doi.org/10.1016/j.surg.2010.11.012

Marzano, R. J., & Kendall, J. S. (2007). *The New Taxonomy of Educational Objectives* (2nd ed.). Corwin Press.

McGrath, J. L., Taekman, J. M., Dev, P., Danforth, D. R., Mohan, D., Kman, N., Crichlow, A., & Bond, W. F. (2018). Using Virtual Reality Simulation Environments to Assess Competence for Emergency Medicine Learners. *Academic Emergency Medicine*, *25*(2), 186–195. https://doi.org/10.1111/acem.13308

Melo, M., Bentley, E., McAllister, K. S., & Cortez, J. (2019). Pedagogy of Productive Failure: Navigating the Challenges of Integrating VR into the Classroom. *Journal of Virtual Worlds Research*, *12*(1), 1–21. https://doi.org/10.4101/jvwr.v12i1.7318

Nirhamo, N. (2019). *XR Studio created virtual learning environment with Hololens for Perho Culinary, Tourism & Business College*. Softability.

Object Management Group. (2021). *Unified Modelling Language*. https://www.uml.org/

OECD. (2018). *Working Together: Skills and Labour Market Integration of Immigrants and their Children in Finland*. OECD. doi:10.1787/9789264305250-en

Oh, D.-S., Phillips, F., Park, S., & Lee, E. (2016). Innovation ecosystems: A critical examination. *Technovation*, *54*, 1–6. https://doi.org/10.1016/j.technovation.2016.02.004

Ota, D., Loftin, B., Saito, T., Lea, R., & Keller, J. (1995). Virtual reality in surgical education. *Computers in Biology and Medicine*, *25*(2), 127–137. https://doi.org/10.1016/0010-4825(94)00009-F

Pallot, M., Trousse, B., Senach, B., & Scapin, D. (2011). *Living Lab Research Landscape : From User Centred Design and User Experience towards User Cocreation. In First European Summer School 'Living Labs', Inria (ICT Usage Lab), Userlab, EsoceNet*. Universcience.

Pandey, S. C., & Pattnaik, P. N. (2015). University Research Ecosystem: A Conceptual Understanding. *Review of Economic and Business Studies*, *8*(1), 169–181. https://doi.org/10.1515/rebs-2016-0021

Pasila, A., & Sutela, H. (2019, April 12). *Ulkomaalaistaustaisten työllisyysaste eroaa rekisteri- ja haastattelupohjaisissa tilastoissa* [Employment rate of immigrants is different in statistics based on registers and interviews]. https://www.stat.fi/tietotrendit/blogit/2019/ulkomaalaistaustaisten-tyollisyysaste-eroaa-rekisteri-ja-haastattelupohjaisissa-tilastoissa/

Ritala, P., & Almpanopoulou, A. (2017). In defense of 'eco' in innovation ecosystem. *Technovation, 60–61*, 39–42. doi:10.1016/j.technovation.2017.01.004

Ståhlbröst, A., & Holst, M. (2021). *The Living Lab Methodology Handbook*. https://www.ltu.se/cms_fs/1.101555!/file/LivingLabsMethodologyBook_web.pdf

Statistics Finland. (2021). *Persons with foreign background*. https://www.stat.fi/tup/maahanmuutto/maahanmuuttajat-vaestossa/ulkomaalaistaustaiset_en.html

Steen, K., & van Bueren, E. (2017). The Defining Characteristics of Urban Living Labs. *Technology Innovation Management Review, 7*(7), 21–33. doi:10.22215/timreview/1088

Torrico, D. D., Han, Y., Sharma, C., Fuentes, S., Gonzalez Viejo, C., & Dunshea, F. R. (2020). Effects of Context and Virtual Reality Environments on the Wine Tasting Experience, Acceptability, and Emotional Responses of Consumers. *Foods*, *9*(2), 191. https://doi.org/10.3390/foods9020191

Tsujimoto, M., Kajikawa, Y., Tomita, J., & Matsumoto, Y. (2018). A review of the ecosystem concept— Towards coherent ecosystem design. *Technological Forecasting and Social Change*, *136*, 49–58. https://doi.org/10.1016/j.techfore.2017.06.032

Unity. (n.d.). *Unity*. Retrieved November 29, 2021, from https://unity.com/

VR Fast Track Project. (2021a). *Health Care VR Implementation (video)*. https://video.haaga-helia.fi/media/VR - Assisted Living/0_l1mgekua

VR Fast Track Project. (2021b). *Restaurant Work VR Implementation (video)*. https://video.haaga-helia.fi/media/VR - Restaurant Work/0_3hp1qcp1

VR Fast Track Project. (2021c). *VR implementation for cleaning (video)*. https://video.haaga-helia.fi/media/t/0_7wrayri7

VR Fast Track Project. (2021d). *VR implementation for medication dispension (video)*. https://video.haaga-helia.fi/media/t/0_ccy3580i

Wallach, H. S., Safir, M. P., Samana, R., Almog, I., & Horef, R. (2011). How can presence in psychotherapy employing VR be increased? Chapter for inclusion in: Systems in health care using agents and virtual reality. *Studies in Computational Intelligence, 337*(2009), 129–147. doi:10.1007/978-3-642-17824-5_7

Wiggins, G., & McTighe, J. (2006). *Understanding by design* (2nd ed.). Perason Education.

Witting, M. (2019, September 16). *Korkeasti koulutettuja ja vähän koulutettuja – ulkomaalaistaustaisten koulutuksesta tulossa tarkempaa tietoa* [Highly educated and less educated - additional information on the education level of immigrants coming up]. https://www.stat.fi/tietotrendit/blogit/2019/korkeasti-koulutettuja-ja-vahan-koulutettuja-ulkomaalaistaustaisten-koulutuksesta-tulossa-tarkempaa-tietoa/

World Economy Forum. (2020). *Jobs of Tomorrow: Mapping Opportunity in the New Economy*. Author.

ADDITIONAL READING

Chesbrough, H. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harward Business School Press.

De Witte, N. A., Adriaensen, I., Broeckx, L., Van Der Auwera, V., & Van Daele, T. (2021). Cross-cultural differences in user-centred research: An international living lab survey. *Health Informatics Journal*, *27*(3). Advance online publication. doi:10.1177/14604582211038268 PMID:34424056

Kauppinen, R., Drake, M., Lindblad, J., & Ranta, J. (2021). From Worklife Competencies to Educational Virtual Reality Implementations. *ICIE*, T2022.

Oculus. (2020). *Oculus Quest*. https://www.oculus.com/quest/

Schluse, M., & Rossmann, J. (2016). From Simulation to Experimentable Digital Twins. *IEEE International Symposium on Systems Engineering*, 1–6.

Zheng, L., Xie, T., & Liu, G. (2019). Affordances of Virtual Reality for Collaborative Learning. *Proceedings - International Joint Conference on Information, Media and Engineering, ICIME 2018*, 6–10. 10.1109/ICIME.2018.00011

KEY TERMS AND DEFINITIONS

Competence: The ability to do something.

Ecosystem: Distributed and adaptive system that has ability to self-organize, scale and be sustainable.

Learning Objective: Statement that define an expected goal of a study unit.

Learning Taxonomy: A way of describing different aspects and levels of learning something.

Living Lab: A user centered innovation system.

Stakeholder: A person or organization with an interest to an issue or entity and ability to affect it.

Virtual Reality: The use of modeling and simulation to enable interaction in an artificial sensory environment.