WORK LIFE RELATED VIRTUAL LEARNING (XR) ENVIRONMENTS FOR BIOMEDICAL LABORATORY SCIENCE AND PERIOPERATIVE NURSING IN THE FUTUREEDU PROJECT

Anssi Mähönen[1], Sirkka-Liisa Halimaa[1], Paola Kontro[1], Jaana Heiskanen[2], Tommi Kinnunen[1], Susanna Vuohelainen[1], Kimmo Pakarinen[1]

[1]Savonia University of Applied Sciences, School of Health Care, Kuopio, Finland

[2]Savo Vocational College, Social and Healthcare, Kuopio, Finland

Abstract

The aim of the project is to create virtual environments enabling time- and place-independent learning, lifelong learning for professionals and online training in authentic environments. These environments improve availability, diversity and quality of healthcare education. The virtual learning environments utilize authentic and work life related learning environments taking advantage of different kinds of virtual technologies, like extended reality (XR). The target groups are students, teachers and professionals in the field of clinical laboratory and perioperative nursing. The international co-operation is with Bulgarian partners. The project is carried out between 2019 and 2021 and is funded by the European Social Fund (ESF).

A Matterport camera to get 3D models of real hospital environments was used to scan the learning environment. This 3D virtual tour was created to enable the participants to become familiar with their own workplace and procedures in advance. In addition, we have used VR glasses and interactive videos in the learning and familiarization process of laboratory equipment and procedures. AR and smart glasses were used to provide a live connection between the clinical laboratory and the university classroom. AR technology was also used for identification and learning of instruments.

During the project, three Matterport-based learning environments, several XR simulations and AR applications were created for a clinical laboratory, operating theatre and equipment maintenance. The created environments will be tested in spring 2020. The material is collected through quantitative and qualitative questionnaire to analyze their utility.

The growing shortage of skilled health workers in the labor market demands an improvement in the quality and access of education. Authentic spaces, equipment and processes can be studied regardless of time or location. The independent study releases resources from professionals. As a result, the studies and work life are more integrated.

Keywords: *XR, Virtual Reality, Higher Education Institution, Healthcare, technology*

1. INTRODUCTION: THE AVAILABILITY OF HEALTHCARE TRAINING

European countries are undergoing structural changes in their labor markets and societies, due to the demographic challenges and ageing, migration and unemployment. Changes in society are also reflected in education. In European countries, digitalization and the access to education have been set as one of the most important priorities to counteract these challenges (1). Higher Education Institutions are undertaking unique methods to improve the quality and attractiveness of education and training that enhance the lifelong learning of the diversified working force.

Finland, as well, is undergoing major changes in society and in the labor market, which is reflecting in the growth of new areas, and structural changes in certain sectors. The country is, in particular, facing an increasing shortage of healthcare workers, such as nurses and biomedical laboratory science (BMLS) professionals. The currently ongoing Social and Healthcare reforms urged to improve the quality and access of health services and response to the increasing demand for healthcare workers (2). There are many reasons for the shortage of healthcare workers (See Figure 1.). Less people are choosing to work

in health care due to the relatively lower rate of salary and challenging working conditions. In addition, education and training is not available in the regions where the demand is high. (3)

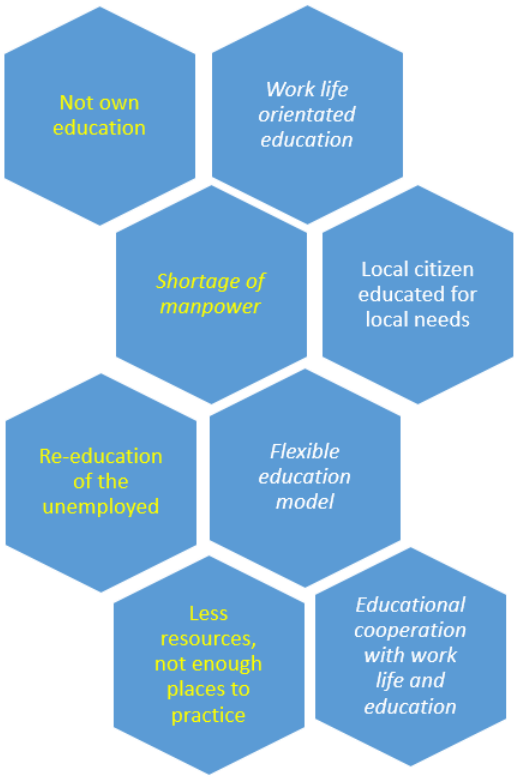


Figure 1. Challenges (in yellow) in society and in the labor market are forcing us to find new solutions (in white) like work life orientated education where local citizens and their needs are in the centre. (Figure by Anssi Mähönen)

Since 2014, Savonia University of Applied Sciences (UAS) has started to build flexible digital learning environments to increase the attractiveness of education and to educate more work life oriented professionals. Savonia's strategic goal is to provide education and training in a variety of flexible ways. One of these main initiatives has been the Satellite education model (Figure 2.), which refers to the implementation of teaching on satellite campuses, allowing students to study in their own home cities using digital solutions. The Satellite education model further supports lifelong learning and aims to meet the rapidly changing requirements of work life. Education and work life are in direct interaction, empowering experts with a strong commitment to their professions. One important component of this model includes virtual learning environments, which enhance flexible learning. Virtual learning environments allow studying, for example, at home or at work, regardless of time and place. In this model, the role of the teacher becomes a builder of learning environments, a learning instructor and a competence assessor. Furthermore, this new education model is cost-effective, work life and student orientated.



Figure 2. Students are studying on three different campuses. The distance learning, called as satellite education, was started between Savonia UAS and two central hospitals. Theory lectures of distance learning were implemented through a Zoom -video connection (Photos by Sirkka-Liisa Halimaa).

The positive experiences of this model and initiative have given Savonia UAS an active role in developing educational solutions based on digitalization and new modern technologies like XR - technologies. The new efforts in using virtual environments, like the Satellite education model, increase training in regions where the demand for labor is high and also permit international mobility and internationalization.

In this article, we will present one of these initiatives, which is the project Future Technologies in Education, FutureEdu (2019-2021). The project aims to develop the supply, attractiveness, diversity and quality of healthcare education through virtual work-based learning environments. Virtual technology, including XR, will be used to create the virtual learning environments (VLE) of clinical laboratory, operating room and equipment maintenance targeted for teachers, students and professionals in the nursing, instrument maintenance and BMLS fields. To respond to the demands for the labor force, the VLE are created with the close involvement of work life representatives. The project's national partners include the Savo Consortium for Education, Kuopio University Hospital and HUSLAB laboratory from Lappeenranta. To exchange knowledge with European counterparts, Bulgarian Ruse University Hospital and The University of Ruse, Yatrus Foundation and Bulgaria, Private Professional College on Social Activities and Security are involved.

The article will highlight the process and explain the methods used in the creation of VLE. The usability of the VLE will be tested by using questionnaires focusing on the technical and pedagogical use of the digital learning material. The research will look at how the new methods accomplish the required learning competences of healthcare education.

The result of the undergoing project is that the new VLEs further develop the Satellite education model from the perspective of learning and teaching. In the long run, we expect that this method will alleviate the shortage of healthcare professionals and enlighten the attractiveness of such a valuable field.

2. MATERIAL AND METHODS: ADVANCED TECHNOLOGIES FOR EDUCATION

2.1 Virtual Learning Environment

Virtual Learning Environment is a system for learning and teaching using the internet and special software (the definition of *VLE* in Cambridge Dictionary). VLEs are found in different types and levels depending on the development stage and field of study. Several studies have suggested that VLEs supported by other advanced technologies such as VR or AR are an effective way to update teaching material and innovative teaching methods. Such a VLE can enhance, motivate and stimulate learners to understand a certain event. (4) (5)

The VLEs, created in the FutureEdu -project, include the following items which are incorporated in each involved organization´s own educational platform.

For BMLS:

- Self-study material: "Safety in Clinical Laboratory"
- Virtual tour in Clinical Laboratory environment (equipment, methods and clinical study process)
- Virtual Microscoping
- Live tour in Central Pathology Laboratory
- Mobile app for identifying laboratory tools
- MR headset guided training

For Perioperative nursing and Instrument Maintenance

- Medical simulations (VR4 Healthcare)
- Virtual tour in Operating Theatre and Instrument Maintenance Unit
- Mobile app for identifying surgical instruments

2.2 Steps to elaborate a VLE

The process of developing VLEs for healthcare education is complex. The selection of the particular case comprises a great deal of dialogue between healthcare professionals, educators and computer sciences experts. The first step was to identify some of the critical procedures, where students have more challenges to learn during their studies. New solutions were based on the need to improve teaching, which is time-consuming because of the familiarization of processes and environments, and repetition of work processes. The introduction of new learning methods should benefit the users and improve their learning process. The identified development cases are part of an academic teaching module for students and continuing study material for professionals. (6) (7)

The VLEs chosen were based on the selected cases of healthcare fields, represented here by BMLS, perioperative nursing and instrument maintenance. Below we have described the methods to create VLEs and the equipment used as part of them. Each of the methods used respond to the particular pedagogical and technical usability to ensure the successful learning outcomes of the user. Particular attention was paid to virtual reality, which has proven to have many advantages in teaching educational objectives.

2.3 Equipment and Methods

3D 360 virtual tours, instrument and tool recognition application, live streaming via GoPro camera, smart glasses based remote assistance and workflow management, and VR (virtual reality) environments are being developed and tested during the project.

Matterport- virtual tours provide a 360° -view and three-dimensional dollhouse model of all types of built spaces enabling the user to move freely and explore in detail the virtual environment. Various information contents can be produced for the described spaces according to the specific needs of the

users. In this project the Matterport Pro2 3D camera was used for shooting and the spaces were stored in the Matterport Cloud.

VR (virtual reality) is a simulated experience that can be similar to or completely different from the real world. Applications of virtual reality can include entertainment (i.e. video games) and educational purposes (i.e. medical or military training). The Unity (2019.2.9f1)-game engine was used to create a virtual environment where the player can practice the use and parts of the **Light microscope**. The 3D-model of the Olympus CX41 light microscope was used as a prototype. The prototype was modified using the Blender 3D modeling program (version 2.80). HTC Vive pro was used as a virtual reality platform.

In addition, the FutureEdu -project acquired a ready-made VR simulation and a customized VR environment. The ready-made VR simulation from VR4 Healthcare included various VR-simulations and VR-skill labs for perioperative nursing and nursing in general. The customized VR environments describe different work processes done in the clinical laboratory and operating theatre. The development process of the customized VR is multifaceted and consists of a detailed manuscript, images, videos and 3D models created by the customer. This material is the basis for the preparation of the VR simulation. Throughout the whole process, the customer and the producer work together to ensure that the end product is desired and pedagogically functional. At the end of the process, the product is tested, errors are corrected and, if necessary, the product is further developed.

Mobile application for instrument recognition uses image recognition and machine learning to identify instruments and equipment. The machine learning platform (TensorFlow, Made by Google Creative Lab) and machine learning model software (Teachable Machine, Made by Google Brain Team) were used to identify instruments and equipment commonly used in the operating room and clinical laboratory. Android Studio was used to write the code. The functionality of the application was tested on a Samsung Galaxy S7 smartphone.

Mixed reality (MR) is a combination of real and virtual worlds to create new environments and visualizations, where real physical and unreal digital objects co-exist and interact in real time. In the MR view a user can navigate this environment and interact with both real and virtual objects. MR headsets are used to get a wireless and immersive view. In this project, we used the Microsoft Dynamics 365 guides -software together with Microsoft HoloLens smart glasses (1st generation). This mixed reality application enabled students and professionals to learn step by step certain processes while they are accomplishing their tasks e.g. in clinical laboratory.

A **Live streaming with GoPro** camera was tested in clinical laboratory environment. With the GoPro camera with live streaming it is possible to share, for example, authentic situations in working life and utilize this live streaming during lessons. The live streaming was implemented using a GoPro 7 camera. A private Facebook account was used as a channel to transmit video for the lessons.

3. RESULTS

3.1 Virtual products for healthcare education and work life

The novelty of the FutureEdu project is VLEs created together by education and work life, based on real work life environments. They offer students and professionals a new way to learn. The virtual environments created in the project utilized virtual, mixed and augmented reality, which were created using a wide variety of hardware and many XR technologies.

Virtual learning environments enable time- and place-independent learning and familiarization with work processes. A virtual learning environment related to laboratory safety was created in the Clinical Laboratory environment of HUSLAB's unit in Lappeenranta. The virtual environment is based on the Moodle learning platform, which contains a variety of texts, images and interactive video materials. The learning materials are accessible through the organization intranet and available to the staff and students regardless of time and place.

Matterport captured images of the Clinical Laboratory of HUSLAB's unit in Lappeenranta, the surgery unit of Kuopio University Hospital (KUH) and the equipment maintenance of Servica Oy to create 3 different 360 degrees learning environments (Figure 3). Various contents such as images, text and interactive videos were included in the environments to allow students and professionals to independently learn the work equipment, instruments and related activities. From the same 360°/3D environments, different versions were created according to both the needs and requirements of students and staff.



Figure 3. Matterport image of operating room (Photo by Mediapointti Finland Oy)

VR (virtual reality) environments were acquired and designed for both the operating room and the clinical laboratory. VR simulation of a light microscope was created to practice the use and structure of the microscope (Figure 4). This was produced at Savonia UAS as a bachelor´s thesis in Degree Program in Information Technology (8). In the VR simulation environment, the user is able to practice the use and setup of the light microscope. In addition, the project acquired a VR simulation from the company VR4 HealthCare, which generates virtual simulations and skill labs. The environments enable practicing various nursing procedures, such as preparation of surgical procedures, skin disinfection, wound sewing and hand hygiene.

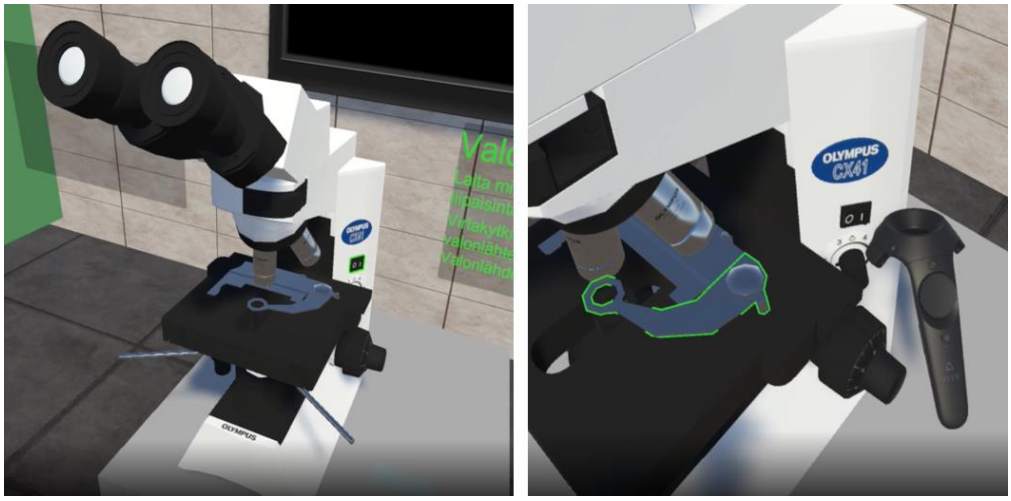


Figure 4. VR simulation of a light microscope (Photos by Anssi Mähönen)

3.2 Preliminary results from students

Second year nursing students at Savonia UAS tested the VR application (VR4 HealthCare) of the operation room, more specifically, a simulation on the skin disinfection procedure. The VR used compensated a part of the simulation lessons of their nursing degree program. First, the students were well informed and instructed on how to use the VR application by the teacher and the tutorial video, included in the application. For about half an hour, a student tested the application and was after that asked to answer the questions of a survey on the usability (technical and pedagogical) of the VR environment. The users considered their ICT skills mostly good but none of them had used the XR environments before.

The results highlighted the technical usability of the digital learning material as good, giving a score of 4 out of 5. The VR environment was experienced as an interesting way to promote learning. The learning material was easy to use and all relevant information was easily found. In addition, the virtual game was found to be functional and the simulation progressed smoothly forward. The user, however, needed more instruction on the type of commands and movements necessary to do a particular function in VR. A student stated that

"*Usability would also be better and make it easier to operate and set up if some instruction on the movement required to be performed in the VR environment was included, either above or next to the function – e.g. a finger pointing to wear gloves…" (Translation from Finnish)*

"Otherwise an interesting situation, but the fine motor skills are still clumsy, e.g. to grasp object: the cursor must be just in the right place, otherwise you can take other objects or no object at all".

The results also gave insights into the pedagogical aspects of the VR environment, where the average score given was of 4.1 out of 5. The users considered that the study material was suitable for the subjects being studied, relevant to their profession and added value to learning, compared to the traditional methods (textual materials and lectures). However, more attention should be paid to the way of increasing the knowledge of the study topic and including more useful and sufficient feedback on the learning process. In general, the VR environment was suitable to practice by repetition, to learn what steps to follow, to understand the overall procedures, to understand the critical steps that need to be taken into account. Yet, it does not accurately measure how well the students´ skills develop. The students´ statements well express the goal of the VR environment:

"….the VR environment advises well how to proceed in a particular situation and teaches also how to do it. Definitely suitable, for example, for a pre-workshop review before a simulation or for an independent review of a topic.

"It will be useful in the future, to practice at home or elsewhere outside the school if the VR can be used on Kinect or Wii consoles, as a way of supporting the learning and reviewing the material"

"The VR environment works when you don't need the so-called skin contact. For example, the order of a procedure will certainly be better remembered in that environment. For example, drug distribution or asepsis, etc. where there is no direct patient contact."

These results are preliminary and due to the Corona virus pandemic, a more experimental testing was postponed until autumn 2020. However, on the basis of the results it can be concluded that a VR environment is very useful to promote independent learning and repetition of the clinical processes, but not quite well accurate in measuring the detailed skills of performances where fine motor skills are needed.

3.3 The need for a customized VR simulation

The project is currently implementing new customized and authentic work life VR simulations for the clinical laboratory and operating room. The VR simulation of the clinical laboratory focuses on the histological process of the pathology laboratory, covering the laboratory testing process of sample taking carried out by a biomedical laboratory scientist. The laboratory testing process begins with a tissue sample or organ that has arrived in the department of pathology laboratory and always ends in a high quality and well dyed tissue section. The operating room-related simulation focuses on the tasks of the

perioperative nurse before the patient enters the operating theatre. These steps include testing an anesthesia device, monitors and suction equipment, as well as preparation of medications and infusion fluids. Simulations of both of these clinical environments include both tutorial and testing sections in the education content.

The project also pursued a customized VR learning environment. The procurement process of the acquisition was multi-staged and demanding due to the novelty of the item. As far as we know, this process had not been documented anywhere else. At the first stage, the experts decided which of the most critical working tasks were suitable for VR learning environment to be created. After that, the Canvas planning tool was used to create the learning environment, describing the goal and learning outcomes, target group, and users. The canvas served as a way to consider and discuss the draft of the virtual environment, look at the required content, graphic style, schedule, budget as well as the learning feedback and the interactions. The Canvas served as a platform for discussion and planning between the customer and the producer of the learning environment. The next step followed the creation of the manuscripts for the learning environments, with supporting videos and images about the working life to clarify the desired environments and their functions. Finally, a call for tenders was written which included the Canvas, manuscript, videos and images attached. Based on the tenders received, the most suitable producer was selected and a procurement contract was made between the customer and the producer, which specifies the details of the implementation.

3.4 MR and advanced technology as a part of the learning process

A mobile application for identifying equipment makes it possible to identify both operating room instruments and laboratory equipment. This application is suitable for students´ independent study when they want to learn, identify and name a different health care equipment. The application contains a menu where there are different sections to choose from, like image recognition, QR-code recognition or data/image library. In the image recognition part, the student can take a photo of the desired instrument or equipment, and based on this photo, the program tells the name of the instrument/equipment and also gives more information about it. In addition, QR-codes could be used for identification (optional). The library section contains images of and information on all equipment and instruments created in the system.

HoloLens e.g. enables new experiences that show where a certain object is located and how certain processes e.g. in the clinical laboratory or operating theatre progress. HoloLens glasses were used to systematically instruct on the use of the laminar flow hood in the clinical laboratory. The learner's hands are then free and he or she can work following the instructions given through the HoloLens.

As a part of the biomedical laboratory students´ theoretical studies of the histological and cytology process, live video connections were arranged between Savonia UAS and the hospital's clinical laboratory. First the laboratory testing process was discussed in theory and then the same process introduced through a live video connection from the hospital laboratory. The work life representative showed how the histological examination process progressed in a real clinical laboratory, and thus the theoretical knowledge the students had gained beforehand got an authentic work life context. This enabled close co-operation and interaction between work life and education regarding the learning process, as well as it broadened the students´ understanding of the authentic work environment.

3.5 VLE in transnational cooperation

As XR is rapidly developing across the globe, Europe being one of the strongest players, the FutureEdu project is also concerned to cooperate with other European countries to explore new possibilities in the field. The Bulgarian partner organizations, Yatrus foundation and University of Ruse, are well committed to developing new ways of enhancing innovation in their societies. The aim of the cooperation consisted of exploring the potential of new technologies such as XR in contributing to improve the work life skills and the quality of education in both countries. The cooperation focused mainly on the exchange of information, highlighting the best practices, and developing the joint virtual products.

The first stage of the cooperation included sharing of knowledge, whereby a comparison of the virtual technologies and environments, suitable for education and practical training in international cooperation, was completed. The use of XR and the identification of good practices, frequently used hardware and software were evaluated during several meetings and encounters. The meetings involved representatives of the regional hospital, companies and educational centers.

At the second stage of the project, the selection of the VR environment suitable for international educational co-operation was done. Two items were chosen for development, *the XR training* module and *the Internationalization at Home* virtual module. These modules aim to increase the international partner's skills in XR development, internationalization at home and to enhance the use of XR in higher and vocational education.

At the third stage, experiences and project results were disseminated through conference participation, publications and a specific manual on the use of XR. The manual will give an overview on how XR could be used in different expertise fields including health care, architecture and tourism among others.

The XR training aimed to improve the participants´ professional knowledge and computer technology skills to enhance innovation solutions in their own professions. The participants represented the fields of architecture, computer sciences and culture. The training provided theoretical knowledge and practical basic skills needed to create products that utilize XR and 360 technologies. The course included an intensive study week at Savonia UAS, covering topics such as the basics of software, game engine development, video production and virtual tours, the basics of 3D modeling and entrepreneurship. The participants developed virtual tours of parks, working spaces and tourist places using virtual reality or 360 content. The overall feedback on the training was excellent. All participants fully agreed that the training gave new ideas and insights into developing their professions.

The internationalization at home module is for healthcare professionals and students in the field of perioperative nursing, instrument maintenance and biomedical laboratory science. The module consists of information about health and education systems in different countries and VLEs from the operating room, medical laboratory and instrument maintenance room. Each VLE covers a virtual tour with additional material and tasks. After the module is accomplished, participants will understand the healthcare system of Bulgaria and Finland, the culture and life style in both countries. The module enhances and encourages the use of virtual material in education and increases internationalization and the exchange of experiences. In addition, participants are more prepared to start their exchange period abroad, if desired. The module was developed by a multidisciplinary team consisting of members from Yatrus Foundation, University of Ruse from Bulgaria, and Savonia UAS and the Savo Consortium for Education from Finland.

4. DISCUSSION

Structural changes are taking place in societies and affecting Finland and other European countries. Digitalization, for this part, also creates a framework for how societies can succeed in this changing environment. It also challenges education and old practices to develop into more functional, flexible and digital methods. In particular, the pandemic caused by the Covid-19 virus has changed the world and forced education worldwide to be transferred into distance learning and start using online and virtual learning environments.

This article described the authentic VLE for work life produced in the FutureEdu project, which was developed together with work life representatives and can be utilized by both students and professionals being already familiar with work life. In work life, versatile competences are needed that can now be realized through these new learning environments such as work life is at present. This is how education is at the heart of work life. Although Finland is one of the world's leading countries in digitalization, these VR environments created for healthcare education are unique and the first ones in health care education in the whole country.

Virtual Learning Environments and their content increase learning opportunities, especially, when traditional classroom teaching is not appropriate because of the student´s personal life situation. The

need for continuing learning requires an effective education model that allows for the training of a large number of new professionals as described in the Satellite education model above. Virtual technology together with the Satellite education model is one possible way of providing training for a larger group in different locations. The aim of the current project is to produce high quality education and equal knowledge for all, ensuring a pedagogically and methodologically sustainable solution, which fulfils the competence requirements of work life.

Good digital learning environments take into consideration different kind of students, enabling learning time- and place-independently. Digitalization makes easily accessible education possible and prevents social polarization and exclusion. This guarantees equal access to education throughout society. In the best case, students in different locations can motivate each other and be inspired to enjoy online learning in a real authentic environment. The training should take advantage of young people´s digital skills, which are usually good.

Teachers and learners are experts in learning, and their knowledge and insights should be used more in the development of digital learning materials in the future. There is a need for interaction and network with work life where to operate and share current information and experiences. Carefully designed virtual learning environments also reduce the need for face-to-face teaching. In future, teachers are working more as mentors and facilitators in education. Creating digital learning environments takes a lot of time and requires expertise of teachers. In addition to the teacher's professional competence, there is also a need for technological competence to which they need support and guidance. The financial issues also put their own constraints on building the environments, as technological solutions are expensive and time-consuming.

The elaboration of virtual learning environments must take into account the target group, the suitability of the technology used, the content requirements and the pedagogical approach. The quality of the utilization of digital learning materials is at its best when the materials are carefully planned and implemented. However, it must always be remembered that the learning process and the learner are always at the heart of digital solutions.

The Virtual Learning Environments created enable international cooperation. Internationalization at home enables the growth of skills and dialogue with students from different countries. At their best, digital environments increase the exchange of knowledge, cultural competence, and joint inter-university studies between different countries. The cooperation with international partners has broadened the understanding of the XR field, giving a wider space for discussion between diverse actors and networks. Growing potential and activities in the XR field are observed both in Finland and Bulgaria. XR is used in some educational programs of Savonia UAS, Finland, while in Bulgaria the use is much common in technological programs but not in health care. The field of health care has proven potential for further collaboration. Despite the differences in culture and the level of XR expertise, cooperation can still bring educational cooperation and joint development projects.

As a conclusion, the project challenges educational institutions to produce digital environments. Although building environments is expensive, time-consuming and challenging, this work done pays for itself many times back with students' strong working life skills.

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