Interreg CENTRAL EUROPE

Co-funded by the European Union

VReduMED

VReduMED Roadmap

Roadmap for the integration of Virtual Reality in care education and MedTech products & services / incl. cluster policy recommendations

Version 1

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1. Introduction to VReduMED

1.1. Virtual Reality in Care Education in Central Europe

VR/AR as a training tool is used prominently in healthcare as these technologies allow training in a variety of scenarios in a safe environment, helping healthcare professionals to rehearse certain situations in a realistic and risk-free format.

According to the Virtual and Augmented Reality Industrial Coalition Strategic Paper prepared on behalf of the European Commission, and based on research by the VReduMED Partnership, Virtual Reality is used in Care Education in Central Europe for:

- Patient care (in particular for psychological disorders such as phobias, addictions, eating disorders or people with limited physical abilities, and to optimise rehabilitation protocols)
- Representation of 3D structures (such as tissues or organs)
- Remote collaborations
- To improve lifestyle habits
- Activities related to the operation of healthcare institutions

1.2. VReduMED Interreg Central Europe Project

Medical interventions are increasingly digitalised, but training of health care and especially nursing staff is still lagging. The VReduMED project – co-funded by Interreg Central Europe of the European Union - helps to untap the potential of virtual and augmented reality for their education.

The main task of the VReduMED partnership – consisting of 10 partner institutions from the higher education sector, business support organisations, medtech and IT companies and practitioners from CZ, SK, AT, HU and DE – is the introduction of Virtual Reality as a human-centered MedTech innovation in the education of care professionals.

VReduMED focuses on enriching the education of care students and the upskilling of care practitioners, in addition to foster the uptake of MedTech assistance systems by the care sector and trigger the co-creative development of demand-tailored MedTech solutions.

Up to date information and activities of the project can be found on the VReduMED website and on the website of the Interreg central Europe website hosted by the European Union.

1.3. Statement of Purpose and Scope of this Roadmap

Technology Roadmaps are intended to support a specific type of technology. The intent of this VReduMED roadmap is to address **MedTech Companies and relevant public authorities (incl. educational sector)** to consider VR as a viable tool for care education to up-skill care staff and students. The main outcomes gathered so far are presented in chapter 3.

This roadmap is a valuable tool to motivate and qualify **VR developers and providers** of VR solutions considering the care education sector as a potential field of commercial interest. It can assist along the path developing and putting on the market novel solutions for the care sector. It gives insights to the stakeholders' needs and particularities based on the findings of the VReduMED project summed up in chapter 4.

Finally, this roadmap is a guide for **cluster initiatives and business agencies**, both on regional and national levels, to develop and implement a guide on how to develop and roll out a plan to utilize VR in care education, adapted to their local needs and how to identify partners for transnational cooperation within the framework of the European commission. These recommendations can be found in chapter 5.

This document delivers valuable information on the technology of Virtual Reality and its usage among the stakeholder group of care educators on a regional and transnational scale and defines concrete measures to be executed in chapter 6.

2. Roadmapping Process

This chapter explains the methodical approach used to create this VReduMED roadmap. It explains the steps taken to generate outcomes that are valuable for the stakeholders within the project. Also, the procedures followed to establish practical recommendations aiming at the establishment of VR in Healthcare are presented, based on respective goals and objectives.

This technology roadmap was developed, considering existing best practice literature like the guide to development and implementation of energy technology roadmaps by the international energy agency.

Establishing a Steering Committee

First, the steering committee was established within the multidisciplinary consortium of VReduMED. This committee ensures that all important aspects of the project are considered and monitored by the according experts.

Selecting Stakeholders and Experts

Experts in VR development and care education were identified, contacted and informed about the project. Within a roundtable setting, those experts were consulted and gave valuable input and feedback. Expert judgement and consensus-building activities form the core of any effective technology road mapping process, conducted in dedicated workshops. Both technology and education experts are involved in relevant steps of the project.

Conducting a Baseline Research

In parallel to the activities described above, baseline research was conducted as an important tool to assess the competences in (medtech) VR and in care education innovation in the Central European region. All outcomes of this research like the competence mapping, good practice examples and the survey of key actors can be found in chapter 3.

Good Practice and Findings

Within the project, various stakeholder involvement activities were performed and lots of input was gathered regarding the implementation of innovative VR projects in the care education sector. Therefore, a part of the roadmap is the preparation of the findings and best practices procedures which should help newcomers to the field of care education providing basic considerations. These findings can be found in chapter 4 of this document.

To address the stakeholders in care education, a VReduMED handbook will to be released as a main output.

Cluster Policy Recommendations

There are several recommendations identified to support transnational cooperation in technological innovation. In chapter 5, the goal was to summarize the European strategies for innovation as well as to name some national and/or regional good practices.

Identifying Measures and Timeline

Concrete goals and measures are developed and discussed in chapter 6. This should provide a clear path to support VR solutions for the care education sector and on the other hand be open for adaptions and add-ons in the future progress.

Analysing Future Scenarios - Ensuring Project Sustainability

To be able to support future innovation in the field of VR in MedTech and care education, the national and regional options for fundings and support must be analysed to identify ways to finance national and transnational projects.

By analysing the regional status quo in one example region (chapter 5), recommendations for cluster policies can be derived.

At the end of the project, a sustainability plan must be established. This roadmap will be handled as a living document and future outcomes like a sustainability plan will be added.

Figure 1: VReduMED steps of the roadmapping process - infographics

3. Baseline Research and Summary of Findings

3.1. Situation Analysis

The integration of Virtual Reality (VR) in the MedTech sector, especially for nursing education, is an important innovation in Central Europe, with a huge potential to improve the quality of education and make it more efficient in the long term.

The research conducted as part of the VReduMED project has identified key central European challenges and opportunities. It highlighted the different levels of VR integration in educational institutions and healthcare organizations in Central Europe. The research highlighted that while some institutions have piloted VR for medical education, usage is inconsistent and there are differences across regions in terms of technological expertise, funding availability and infrastructure. An analysis of current VR capabilities and skills has shown that while there are numerous stakeholders interested in VR, there is a lack of coordination to bring these entities together effectively.

The VReduMED project also found that technological barriers such as motion sickness, usability issues and limited feedback mechanisms in VR simulations are problems that need to be addressed. These technological limitations currently restrict the effectiveness of VR in replicating complex medical scenarios that require fine motor skills or precise human interaction, such as emotional responses.

In response to these findings, the VReduMed roadmap aims to foster collaboration, harmonize standards and address technological shortcomings to create a solid foundation for the sustainable integration of VR into healthcare education across the region.

3.2. Findings

The VReduMED project's comprehensive research resulted in several key findings that form the basis for its strategic recommendations:

3.2.1. Competence Mapping

The first task in the VReduMed project focused on mapping, aiming to assess the current state of relevant competencies in research institutions, the corporate sector, and the existing VR infrastructure within the project region. Building

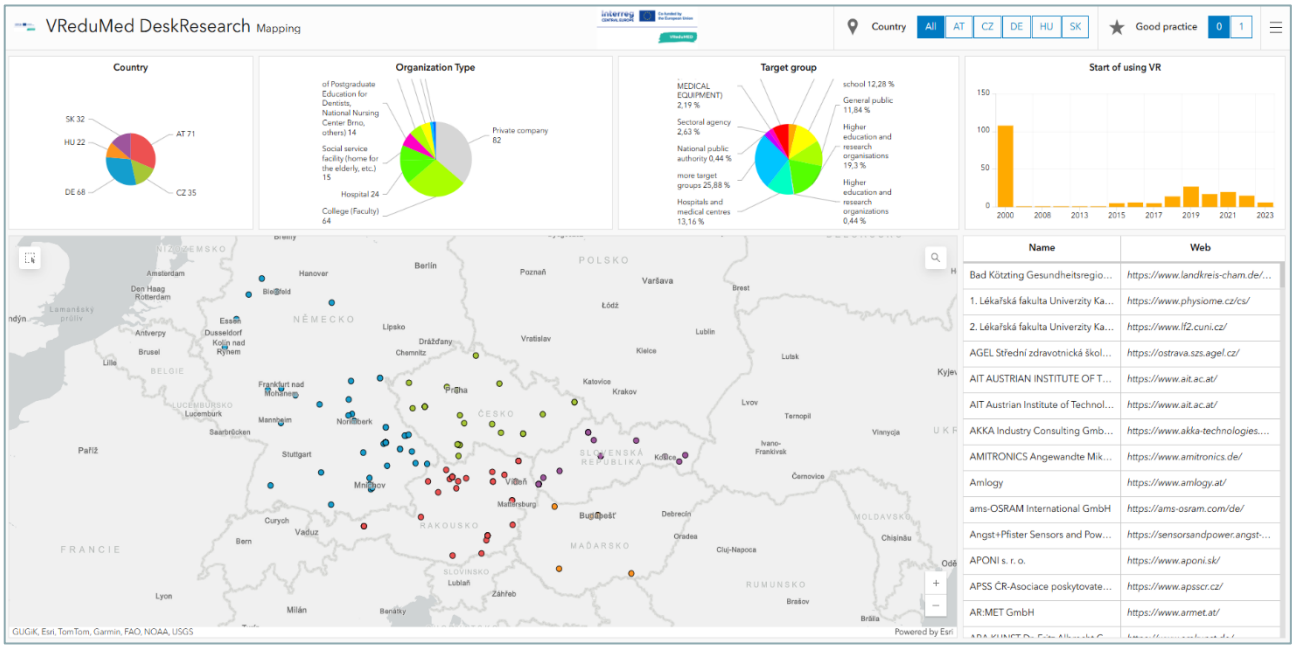

Figure 2: Interactive Webpage Representing VR Competences in Central Europe - VReduMED Competence Mapping

on the experience of the earlier VReduNet project, previous mapping results were enhanced with additional data from all partner regions. This mapping was crucial for the project as it identified key stakeholders, potential partners, and regions with significant virtual reality and healthcare-related activities, gathering over 200 records.

Figure 3: Example of VR in Care Education Good Practice Application (photo © Imsimity)

For visualization, the ArcGIS Dashboard web map application was chosen as the main tool to display the geographical distribution and structure of the organizations, offering deeper insights into the collected data. The application is publicly accessible via the project website (www.vredumed.eu/mapping-surveys), but its primary purpose is to provide a solid data foundation for project members in future activities.

3.2.2. Good Practice Collection

All project partners gathered and analysed good practice examples of VR applications in the broader healthcare sector for use in awareness-raising efforts. These examples were compiled into a good practice catalogue, allowing those interested in VR/AR in healthcare to explore best practices from each project country. Each example is summarized on a single page, providing details about the organization, the target audience, the background of the use case, and the technology applied.

In selecting these examples, partners closely monitored and evaluated the work of local and regional health organizations using AR/VR. This not only gave them insight into notable projects but also improved the quality of discussions within the project consortium. Furthermore, the information collected is valuable for other project tasks, such as selecting participants for events.

The catalogue serves as a resource for target groups to discover inspiring examples of VR/AR use in their regions, potentially guiding their own project planning and promoting VR/AR further. In some cases, it might influence decisions when selecting training institutions or employers.

3.2.3. Survey of Key Actors

VR/AR stakeholders in all project countries provided their experiences via a questionnaire. The questions focused on their experiences with VR or AR technology, focusing on its purpose and potential applications, particularly in teaching and learning. Topics included areas where VR could be beneficial, the main challenges in using it, and its perceived added value in learning scenarios. Participants were asked whether VR can enhance problem-solving skills compared to other methods, the advantages and disadvantages they perceive, how VR was implemented in their organization, and whether its use is growing. They were also invited to share any additional thoughts about VR for training and education in the medical sector.

Evaluations of the questionnaire yielded the following findings: www.interreg-central.eu/wp-content/uploads/2024/11/VReduMED-Survey_1.3.1.pdf

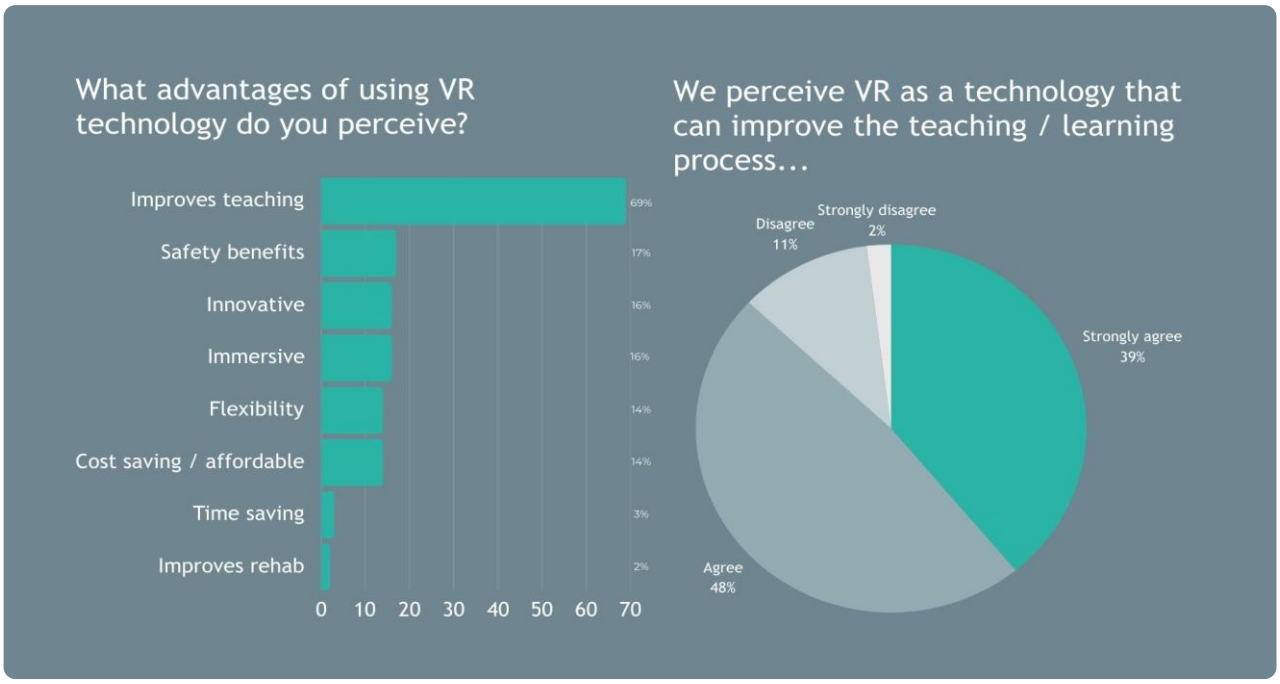

Figure 4: Example Outcomes of Survey for Key Actors

3.2.4. Outcome Round Tables

Round table events were organized in all project regions (CZ, AT, DE, SK, HU). The aim of the round tables was to familiarize future users of VR solutions with the technology and its possibilities, to test existing applications, to obtain feedback on the application and to discuss which scenarios are conceivable or desirable and how they can be integrated didactically into the existing curriculum and where exactly the best possible potential of VR lies. The key question was: how can VR be successfully integrated into the training of nursing staff? The participants were given the opportunity to test VR glasses and applications. This allowed participants to experience VR first-hand, promoting an interactive and productive dialogue. The importance of involving teaching staff through training in VR technology, seeing VR as a complement to traditional methods and focusing on practical teaching concepts such as pre-learning and practical exercises was highlighted. To enable smooth VR integration, guidance on equipment, streaming and rental options was also recommended. Further findings can be found in chapter 4.

3.2.5. Outcome Innovation Sessions

The aim of the open innovation sessions was to develop possible scenarios for VR in care education and medtech together with stakeholders (trainers, nursing students and MedTech suppliers) and with the help of innovative methods and creativity techniques. Healthcare professionals received insights into innovative teaching methods, while developers learned how to tailor solutions to real-world medical needs. Important topics of the workshops contained: Cost, didactic value, usability, variation of scenarios, asynchronous timing, language, haptic feedback, display of motions etc., as well as ideas for specific use cases. Many ideas for potential VR scenarios were collected. These ranged from wound care, endotracheal suctioning to changing dressings to finding a dead person. This large collection of ideas for scenarios then formed the basis for the project consortium to decide, based on international findings, as to which applications would be developed in the project.

3.2.6. Specification of Standard Configuration for VReduMED Labs

Based on extensive experience in the integration of VR hardware and software and considering data protection guidelines, a manual was created in the project to facilitate and support the implementation of VR applications in the healthcare sector. The hardware information focuses in particular on the Meta Quest 3, as these glasses offer the best price-performance ratio. The Meta Quest 3 offers inside-out tracking with multiple cameras and sensors for precise positioning. Due to the extensive data collection, data protection measures are necessary, as location and movement data can be personal and sensitive. Anonymized accounts are used to

Figure 5: Care Expert during Innovation Workshop Experiencing VR (photo © Strategische Partnerschaft Sensortik e.V.)

prevent individual conclusions from being drawn. Data protection officers should ensure GDPR compliance and train employees accordingly. An offline data network enables secure VR use; separate internet access is required for updates. The facilities receive VR glasses free of charge and determine the required number in consultation. Network requirements include at least 25 Mbit/s (download) and low latency times. At least 2.5 x 2.5 meters of free space is required for VR room use, larger areas are recommended. A powerful PC or laptop is suggested as an option. Large screens or iPads can be used to view the VR environment outside the headsets.

3.3. Summary of findings

So far, the situational analysis performed during the VReduMED project has proved the transformative potential of Virtual Reality in Care Education and MedTech. Important information was gathered along the process which will be presented in chapter 4.

4. Integration of Virtual Reality in Care Education

This chapter collects all relevant information, recommendations and sources needed for the successful introduction of virtual reality as an educational tool in care education.

4.1. Stakeholder Groups

Various stakeholder involvement activities have been conducted within the scope of the VReduMED project. The input that was gained from the stakeholder groups is crucial to the success of innovation projects within the scope of VR in care education.

4.1.1. Care (Education) Experts

This chapter displays the input of care educators gathered from various events and workshops within the VReduMED project. This can be valuable information for MedTech companies and VR developers when it comes to understanding the needs and the reservations towards VR of care educators.

Cost of VR:

The (health-)care institutions need to use their funds thoughtfully and thereby weigh up their costs and benefits as efficiently as possible. Thus, the costs of VR equipment as well as development costs for the applications was of key importance, mentioned on several occasions. Consequently, we recognized that a clear analysis of the financial implications of the introduction of VR in care education must be a crucial part of the technology roadmap to be prepared during the project later. Specific workshops will be dedicated to that issue.

Training on the technology:

Current VR solutions and applications may seem quite overwhelming when used for the first time. Some care education experts do not have technology experience, especially in VR. Therefore, those teachers need to be trained on the technology before they can train students to use VR applications. Thus, the need of a train the trainer service should be addressed in the roadmap as well to ensure that the trainers feel confident enough to use the technology and try out new applications.

Didactic added value:

Care educators remarked that VR applications must add a clear value to the didactic approach which is used to teach a certain action or scenario. Multiple issues were mentioned in that context.

The applications to be developed need to provide direct high-quality feedback to the student whether a decision or action was correct and what could and should possibly be improved. Without such feedback, the care educators would not consider an application as suitable for educational purposes.

Speaking of correctness, it is crucial that the information transferred is state-of-the-art and corresponds to what is taught in care education. This means that all contents need to be developed in close cooperation with care and medical experts. Mistakes or misconceptions in content are a no-go for care experts.

The scenarios should be focussed on such situations and setting, that cannot be trained in a conventional setting easily, not resulting in excessive costs and effort. On the other hand, situations and procedures which can easily and most efficiently be trained in a real-life scenario, e.g. in a classroom, should rather remain to be trained in that conventional style. Scenarios like large-scale emergency training operations or exceptional situations for example seem appropriate to be trained with VR.

The added value can also be, that risky procedures which could be harmful to patients can be trained in a controlled and safe way.

Overall, the technology must be reasonably implemented and embedded in the existing didactic concepts.

Time scale of the scenarios

Care (education) experts mentioned that the attention span of the students has decreased due to the short-lived media consumed over social media. The education experts thus suggested to keep the length of the scenarios short and put more emphasis on repetition, rather than developing complex and time-consuming scenarios.

Clear actions and objects

Another recommendation given at the workshops was to give clear instructions for actions and to design object handling as simple as possible. Objects relevant for interaction should be clearly marked, whereas irrelevant objects should rather be removed. If there are irrelevant objects the user cannot interact with, it can cause frustration if the user thinks he or she needs to interact but can't.

Also, correct and incorrect actions must be clearly discernible to the user in order not to trigger frustration and cause a negative learning experience.

Usability

Related to the previous point, it is important to ensure the overall usability of the interfaces and interaction possibilities of the VR training system. Also, the onboarding process student must undergo must not be hindered by complicated handling or hard to perform actions.

Variation of scenarios

As mentioned above, repetition is important and needs to be considered. To prevent scenarios from getting boring and repetitive, variations should be provided. This could be, for example, different settings, different actions, different objects or different objectives.

Misalignment of movements and actions

It was found that asynchronous timing of actions and VR response was a dealbreaker for the users. If that happened, procedures were in fact performed accurately, but the system did not match the response correctly. Such misalignments must be avoided, especially when facing time critical actions like CPR (cardiopulmonary resuscitation) of other medical procedures.

Language

It is crucial that care education scenarios be available in multiple languages. Care students often come from diverse backgrounds speaking different languages and need to have the possibility to train in their native languages. At least an English version should be provided with all applications.

4.1.2. (MedTech) VR Experts

During these workshops and events, contributions from VR developers were also collected that addressed the question of what to look out for when developing VR applications.

Haptic feedback and fine motor skills

Currently there are no available VR solutions to simulate haptic feedback (for example grabbing a glass, resistance of a syringe needle, …) which makes training scenarios involving fine motor skills unsuitable for VR training. The VR technology is not yet at the stage, where solutions to improve skills in that respect can be developed.

Representing emotions

Another limitation of the technology can be the representation of virtual human beings' or NPC's (non-playable character) emotions. Due to limitations of graphics rendering facial expressions needed to adequately display human emotions cannot be "synthesized" with enough precision yet. VR cannot replace social interaction. So, a scenario like calming down an angry patient is currently not suitable to be trained in VR.

Motion sickness

Motion sickness – a strong feeling of discomfort when using VR devices – was a big problem with older VR technology. Experts said that with up-to-date hardware like the Meta Quest 3 or the Pico 4, motion sickness is getting less and less an issue and due to rising resolutions of the VR displays. Also, the problem with eye strain will lessen in the future. Some participants experienced motion sickness but mainly on older generation headsets.

4.2. VR Devices

When VR devices are used in awareness raising campaigns or user workshops with care staff, several points are to be considered.

It was important to have the devices recharged before the demo sessions - mainly when those are standalone, and battery powered devices without constant power connection. At best have an external battery to prolong the time of use. The devices can also be charged by cable, but this complicates the usage and may have a negative impact on the user experience of the participants. Since the goal is to convince the target group that VR is an easy to use and capable technology for education, a bad user experience must be avoided.

Most manufacturers and application developers focus on wireless connection to a high-end computing system (via Wi-Fi connection) or on a standalone device (applications run on the VR device itself). The advantage of this type of setting for the user is that they are not tied to a cable and can move around freely. This should also be preferred for hands-on activities.

As there are many options for VR devices available, research is needed to choose, which technology is best suited for the given use cases. The VReduMED project decided to use the standalone device **Meta Quest 3** as it is state of the art (2024) in its features and does not need to be connected to a high-performance computer. This may lower the graphics quality but makes it easier to handle and cheaper to acquire.

4.3. VR Based Education

During the VReduMED Train the Trainer activities, the technical partners of the project have developed a guide for onboarding care educators to the VR technology and give suggestions for suitable applications to start with and a general educational framework.

These outcomes will be available in the VReduMED Handbook which will be released in 2026 and will contain all valuable information for care educators and on how to integrate VR in the curriculum.

Considering that the trainers (care educators) only have little to no experience in the field of Virtual Reality, an introduction of the technology including its possibilities and the handling of the devices, as well as the definition of AR/VR/XR is important. A step-by-step guide presentation was developed to ensure that the trainers are enabled to use the technology properly.

Next, the use of VR in education is discussed including how VR can help teaching, how to integrate VR into courses and some curricular examples.

Lastly, recommendations on hosting a VR learning session are made and some available applications can be tested to gather experience.

4.4. Importance of VR Onboarding

In the user centred workshops conducted during the VReduMED project, about 50% of participants had no previous experience with the technology. This underlines the necessity to provide some kind of onboarding and hands-on activity in upcoming workshops, to ensure all participants had at least some prior experience with VR. This chapter sums up the main points that have been found to facilitate that process.

4.4.1. Setup of Onboarding

It is important to have a suitable setup of an VR onboarding session. There were multiple points found to make that process easy.

VR experts and screen casting

It is important to have dedicated VR experts explaining the technology and the user interface before the participants can try out the technology. The VR lens used for an introduction/demonstration should be casted to an external monitor which can even be a smartphone screen. It is important to set up the screen casting before the event starts, so that potential technical difficulties can be resolved before they could have a deterrent effect on the unexperienced participants.

The main advantage of screen casting is that the participants of the demonstration can see the user interface in advance and can also see what the instructor is doing. This makes onboarding much more time efficient, because more than one person at a time can be instructed. Participants who are waiting to use a VR headset can watch the others in the meantime.

Another advantage of screen casting is that the instructor can see what the users are seeing and doing and is thus able to give more effective feedback.

If enough headsets are available, every user should be supervised by a VR expert over an external screen to avoid frustrating experiences with the technology.

4.4.2. Demonstration of VR Applications

When the user is familiar with the general user interface of the selected VR headset, he or she is ready to be presented with practice applications in VR care education. For this it is necessary to get in contact with e.g. the VReduMED project or one of the VReduMED best practice providers to get access to such an application.

The instructors should have a sound knowledge of the VR application they are going present, to properly guide the users through the scenarios.

4.5. Location and Setting

Partners used various locations and settings in their workshops. The following chapter shows the experiences and good practices found during the workshops.

4.5.1. Location

Various approaches were used to address the stakeholder groups withing the Open Innovation Sessions.

On-site event

Most of the workshops were conducted at the premises of our VReduMED partner institutions. One crucial factor regarding the location was to have enough space for group work and for VR experience. So, either a spacious room was needed or at least two smaller rooms to have enough space for hands-on sessions.

Considering the input of the previous subchapter (Importance of VR Onboarding), there should also be enough space for external monitors.

Figure 6: Scenario for VR onboarding using screen casting (photo © VReduMED)

Especially when there is a time limit for the workshops, it is important to have everything already set up properly, to avoid reconstructing the room from VR hands-on to workshop setting.

Online event

The main advantage of an online setting is the flexibility it offers and the additional digital tools it can provide. Participants do not need to travel to the event location, saving time and costs.

However, the disadvantage of an online setting is that a VR hands-on experience **cannot** be provided. A partial workaround to ensure that participants can have an VR onboarding and can get some experience is to show videos of best practice applications and to show the handling of the VR device. The instructor's view could be casted to the computer and streamed to the workshop participants, thus providing some "indirect" VR experience.

4.6. Engaging the Target Groups

To support the development of VR solutions in the field of care education and MedTech, communities of interested stakeholders must be established.

VReduMED Magazine

The VReduMED Magazine was implemented within the website of VReduMED. It contains news and interesting projects within the scope of VR in care education and MedTech. The project partners can share content from their regions and address topics to attract stakeholders. Such kind of informational platform can be used to raise awareness on the possibilities of VR in a certain field (like care education) and supports regional innovators.

VReduMED Care Education Forum

The VReduMED Care Education Forum aims to solve the practical challenges of providing hands-on, quality nursing education. The VReduMED Care Education Forum is an opportunity for experts and practitioners to help us innovate practice-oriented VR teaching and learning. It is an international expert committee of specialists in care education from the respective regions, who would like to be more involved in the project through:

- Participating in VReduMED round tables, workshops and other transnational networking events;
- Sharing practical tips and examples from the world of VR in care;
- The opportunity to test VReduMED Labs' pilot applications and prototypes;

Care education experts can register for the forum via the online registration form.

This forum ensures that this stakeholder group can be easily informed about project activities and possible ways to participate.

Networks and communities

Another important way to engage the target group is through communities like on the social media platform LinkedIn.

On the VReduMED LinkedIn and Facebook channels, stakeholders and interested persons can get news on the project and the technology. Nowadays it is important to provide easy to access information on online platforms to ensure reaching the target groups.

Also, Outputs like the Care Education Forum aim to build up a network of stakeholders to ensure the sustainability of the project aims.

5. Cluster Policy Recommendations

To enable European regional business agencies and clusters as well as regional governments fostering innovation in specific fields, it is important for them to understand the European Smart Specialization Strategy (S3) and its significance for the national and regional innovation strategies.

This chapter breaks down the **main S3 concept** and gives recommendations on how these specializations can be identified and used to establish transnational collaboration in certain fields. Also, there are references to relevant regional and national funding schemes which can be used in VR in MedTech and Care Education, based on some central European Good Practice examples.

5.1. European Smart Specialization Strategy (S3)

This section first explains the main principles behind the S3 concept before presenting informative web resources and giving an example of a specific successful implementation. It also provides links to valuable resources on how to carry out a structured process of developing and rolling out a Smart Specialization Strategy.

5.1.1. Motivation and Principles of S3

In 2010, the Smart Specialisation Strategy (S3) was developed by regional and national governments on call of the European Commission, to encourage all European regions to discover their competitive advantage. The basic idea was laid out e.g. in Smart Specialization a Possible Solution to the New Global Challenges (MargaretaRusu, 2013) were S3 is described as *"A tool for the strategy Europe 2020. It is a key solution for avoiding dissipation of the EU research funds and for focusing the research, innovation, human and financial resources on those innovative sectors which are high performing, strategic from a socio-economical perspective, eco-friendly and attractive for investors."*

Since then, the concept has become firmly established in EU regional policy and has fundamentally changed the way European regions develop their innovation strategies by strengthening cooperation at all levels.

These Smart Specialisations are based on three pillars:

1. **Localisation**
   Smart specialisation is a place-based approach, it builds on the assets and resources available on territory.
2. **Prioritisation**
   The main idea of S3s is to concentrate the regional resources on a limited set of areas of competence and strength. These are identified as so-called S3 investment priorities.
3. **Participation**
   S3s rely on stakeholders along the quadruple helix (public sector, research, private sector and civil society) to be engaged throughout the entire strategy-circle. These regional actors are required to support the definition, review, monitoring and implementation of S3 investment priorities.

5.1.2. Practical Employment of S3

To actively use the advantages of S3, Smart Specialisation, the Community of Practice (CoP) is the central node on guidance, networking, support and peer-learning. Besides links to working groups, events and studies based on one decade of experience with S3, the website offers information on the current development of the S3 concept. The website includes the "S3 CoP Observatory", allowing to effectively search for and identify territorial strategies and priorities related to selected territories. This can be particularly valuable if regions for potential

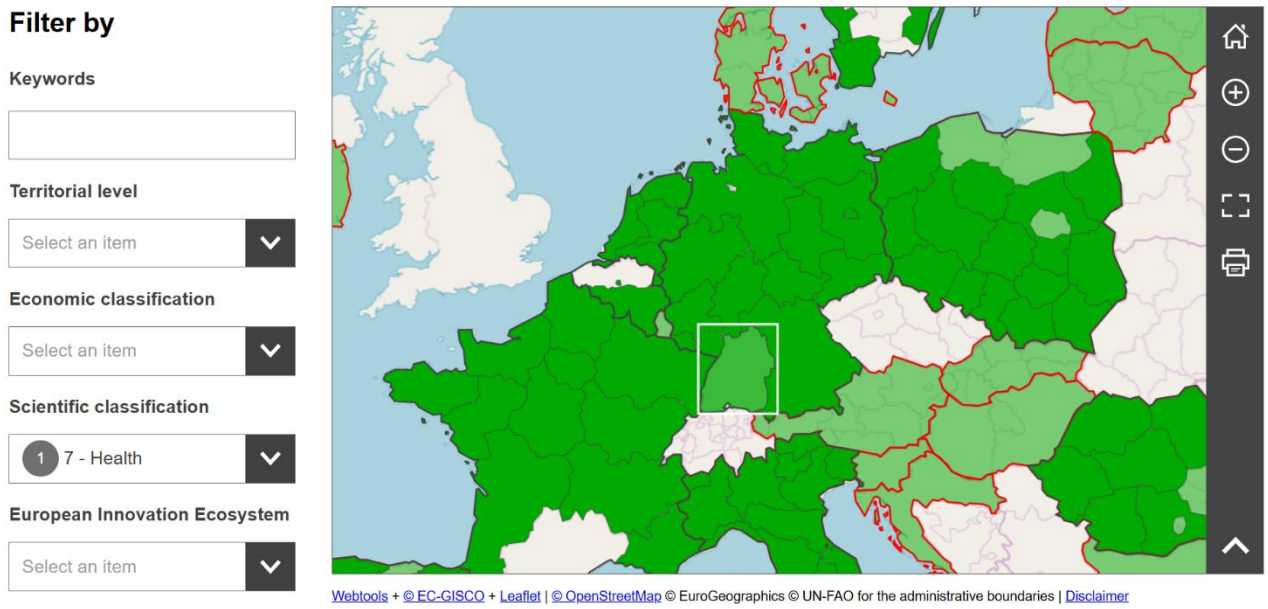

Figure 7: Screenshot of the CoP Observatory Webpage

transnational collaboration are to be identified. A webtool screenshot can be found in Figure 7.

One practice example on how to use S3 for transnational collaboration is the S3-4AlpClusters project, funded by Interreg Alpine Space which ended in 2019. Its objective was to improve the conditions for innovation in the Alpine space. Within this project, several training tools were developed, supporting a systematic process for cluster initiatives and regions to explore capacities and opportunities for transformation, and to facilitate the identification and development of Transformative Activities.

A valuale tool to find partners for transnational collaboration is the Kohesio Webtool to discover EU projects in a specific region.

Another tool which can be used to find partners for collaboration is the European Cluster Collaboration Plarform, listing all registered Cluster Organisations.

5.1.3. Developing S3 Related to VR in Care Education

The overall goal of the VReduMed project is to foster regions in the central European area in creating a strategy and concrete approach to establish the employment of VR tools in care education. To achieve this, developing a regional S3 specifically dedicated to this theme can be a very useful first step. That means that an investigation of regional target and stakeholder groups, strengths and capacities related to both the supplier and the user sides is undertaken, related to VR and care education, respectively.

Instructions how this can be done may be found in various documents on websites related to the Smart Specialization Community of Practice (CoP) mentioned above.

In chapter 3 of the following paper a practical method is outlined how this can be carried out: *"Smart specialization strategies—insights gained from a unique European policy experiment on innovation and industrial policy design"* (Dominique Foray, Martin Eichler, Michael Keller; in: Review of Evolutionary Political Economy (2021).

According to this, the following three steps are the core of any development of an S3:

1. Identifying thematic priority areas.
2. Translating these priority areas into transformational roadmaps to develop transformative activities. Transformative activities are a collection of related innovation capacities and actions oriented towards a certain structural change which is extracted from existing structures and supplemented with extra-regional capacities.
3. Implementing transformative activities with an action plan.

The paper also gives insights into a specific case of an S3 developing project that has been carried out in the Sfax region in Tunesia. Particularly interesting in the context of the VReduMed project, one economic strength of Sfax is in the MedTech area. Thus, a MedTech cluster has been established around the domain-specific quadruple helix (research, industry, policy and society).

The following represents three specific methods which can assist in developing strategies and cooperation.

A: The method of "project mapping"

A practical approach that can be applied to build a transformation activity through an entrepreneurial discovery process is the methodology of Project Mapping, depicted below.

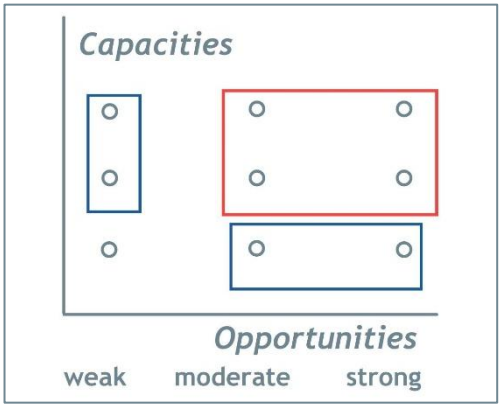

Figure 8: Method of "project mapping" example

B: The 5 Ds

The translation of a priority into a transformative activity is the key transition in the S3 developing process. A useful framework to support this translation is the concept of the "5 Ds". It enables users to achieve good outcomes of an S3 approach, designed to transform the structures of the regional economy, and to be grouped. Measures are thus differentiated into categories of "5 Ds" as follows:

1. ***D***irection of change
2. Relational ***D***ensity
3. Regional ***D***ifferentiation
4. Entrepreneurial ***D***iscovery
5. ***D***istributed capacities

C: Synergy Diamond of transformative activities

The concept of the "Diamond of transformative activities" was developed in the framework of Interreg-Projekt S3-4AlpineClusters. It is designed as a tool to identify potential synergies between regions, based on a structured analysis of their thematic strengths and the relationships between them.

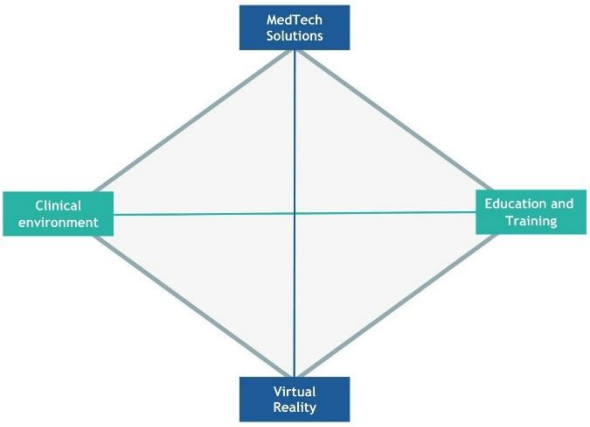

Figure 9: Adapted synergy diamond of transformative activities

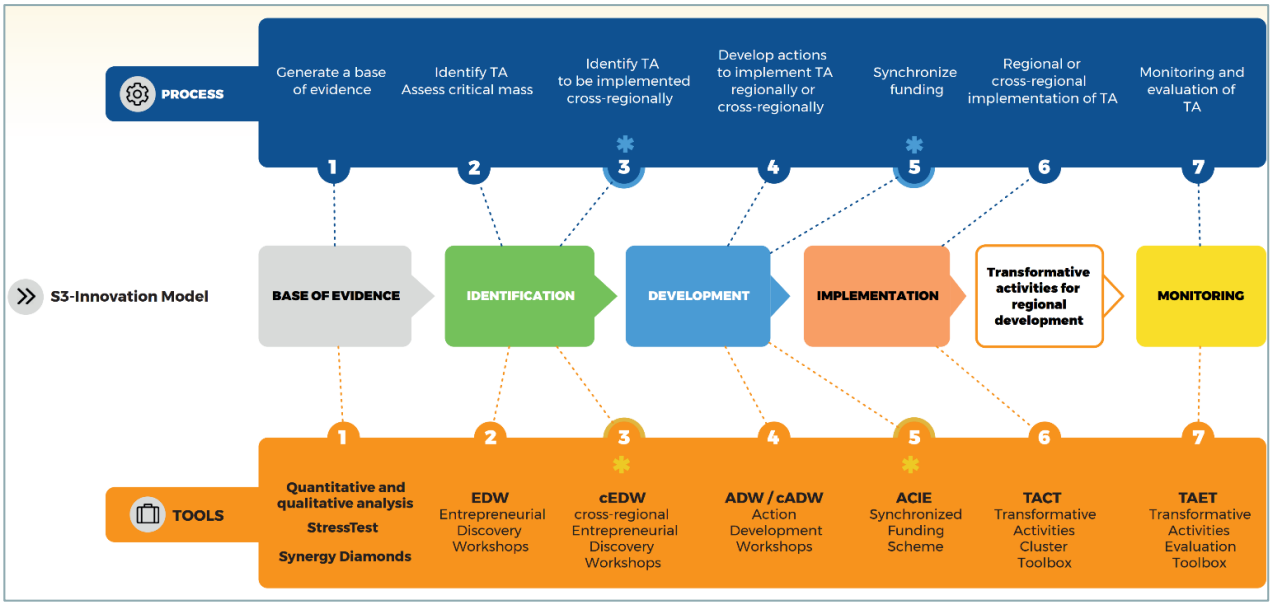

Figure 8: S3-Innovation Model (DOI:10.13140/RG.2.2.34276.63366)

Figure 9 shows an example of a concrete cross-regional (Upper Austria and South Bohemia) "diamond of transformative activities", developed within the S3-4AlpsClusters project. Four focus areas were analyzed and potential fields for collaboration were identified.

To identify those activities on a transnational scale, the "diamond of transnational activities" provides a suitable framework. The process leading to a "diamond of transformative activities" is composed of the following five components:

1. **The creation of a base of evidence** on the region's innovation capabilities.
2. **The identification of transformative activities**: these are activities that have a strong potential for development and innovation by transforming existing industries.
3. **The development strategy for transformative activities**, to define the actions to set up these activities.
4. **The implementation of the actions** in the region, and possibly in neighboring regions.
5. **The monitoring and evaluation of transformative activities**

5.2. National and Regional Implementation of S3

The national and regional funding programmes of European countries are often tightly bound to the S3 strategy. In the S3 CoP Observatory webpage, which was already mentioned above, the territorial strategies can be found, some countries having national, some having regional strategies. Overall, the webtool enables users to intuitively compare Smart Specialisation areas of EU regions and member states, while also providing essential contact points and links to the strategies.

5.3. Transnational Collaboration Through National / Regional Calls

Transnational collaboration can be promoted not only through European funded programmes but also by opening national and regional funding programmes for transnational consortiums. Those foreign partners can also be funded by their own countries' regional or national programmes. Thereby, transnational project consortiums have the possibility to be financed, each using their own funding programmes. The European EUREKA initiative, for example, provides funding support for cross border collaborations across calls.

5.3.1. Examples for Transnational Calls in Central Europe

This section describes examples for transnational funding calls, taken from the example region Austria.

National level

One example on national level would be the Austrian Funding Initiative ICT for the Future supporting research intensive innovation and technology development in the field of information and communication technology.

From this initiative, a call of the Austrian Research Promotion Agency (FFG) named "Virtual Worlds and Digital Solutions for Health" started in 2024. This VR related call provides the possibility for partners outside Austria to participate. Those partners can also be funded by the Austrian FFG, if the following conditions apply.

- The non-Austrian partners create benefit for the Austrian consortium partners and/or Austria as a business and research location;
- This benefit is explicitly indicated in the application for funding;
- Grants paid to partners from outside Austria do not exceed 20% of the total funding amount;
- The evaluation committee recommends providing funding to the non-Austrian partner;
- The partners from outside Austria prove their creditworthiness and liquidity in accordance with the criteria applied to Austrian partners prior to contract formation;
- The non-Austrian partners accept the FFG's obligation and entitlement to review the project as specified in the Funding Contract and submit relevant documentary evidence in German or English.

Alternatively, non-Austrian organizations may cover their costs from own funds and/or from funds provided by their home country. Collaborative agreements for joint funding are in place with several European and non-European countries.

Regional level

One example on regional level, is the Business- and Research cooperation promotion by the federal state of Upper Austria. This regional funding scheme allows companies from other Austrian or non-Austrian regions, to join a project consortium, if it fulfils the requirements of the programme document. Those partners will not be funded by said funding programme but can apply for funding in their own region if there is a suitable reginal programme there as well. One of the key topics of Upper Austria is "Technologies and Systems for People" which fits perfectly for VR solutions in the Care Education sector.

6. Measures and Timeline

This final chapter contains the measures planned and partly already taken by the VReduMED project to support the VR technology to be used as an assistive tool in care education and MedTech. Those measures can serve as a suggestion for other initiatives in this field and can be sources for information for **VR developers, MedTech companies, public authorities and network clusters.**

6.1. Goal of this Roadmap

The goal of this technology roadmap is to provide a strategy on how to use the VR potential in innovative MedTech solutions for care (education) sector. The following chapters will contain information on how this goal will be achieved.

6.2. Gaps and Barriers

As technology in VR is developing very quickly, players in this field must keep up to date and adapt their solutions to the current state of the art. Regarding the target group of care educators, chapter 4 of this roadmap lists some barriers that came up during the implementation of the VReduMED project.

6.3. Measures

This section contains the measures that were and will be carried out to ensure the success of the implementation of VR technology in the MedTech and care education sector.

6.3.1. Short Term Measures

The short-term measures are to be finished within the run-time of the VReduMED project. The following points are thereby being executed between April 2023 and March 2026. These outcomes will be accessible on vredumed.eu.

Displaying VR competences and resources

An initial mapping of relevant competences (research institutions, companies, ...) and VR infrastructure took place and was processed for public use to ensure that stakeholders can access the survey and mapping outcomes online. With the network of VReduMED, the count of projects and partners is constantly increasing.

Introducing interdisciplinary exchange and workshop formats

During the implementation of the VReduMED project, several exchange and workshop formats have been developed and held. These provide the possibility for stakeholders, mainly being VR developers, MedTech companies and care educators to get to know each other and learn about each other.

Outcomes like the needs of care educators, the possibilities of VR and ideas created co-creatively have become important information for the following measures and milestones. Here you can find more information on the VReduMED Roundtables and the VReduMED Workshops.

Stakeholder involvement

An initial awareness raising campaign ensured to reach the stakeholder groups and relevant players. The VReduMED Magazine was established to transport relevant news and information on the topic of VR in care education and MedTech to the stakeholders.

Also there were regional stakeholder involvement activities to update the target group about ongoing development and upcoming pilot actions, as well as a hybrid mid-term event in Hungary.

VReduMED Train-the-trainer actions

The Train-the-trainer programme aims to organise train-the-trainer events so the trained staff can further spread the skills and knowledge on VR/AR systems in their environment.

VReduMED technology roadmap

Addressing the stakeholder groups of VR developers, MedTech companies, public authorities and cluster networks in the European region, this technology roadmap was developed.

VReduMED labs and prototypes

To be able to provide interested stakeholders with an environment and examples to test, the VReduMED lab programme was established in three partner regions and two user centred VR application prototypes are created in 2025 and introduced in pilot actions.

VReduMED Handbook

Addressing the stakeholder group of care education facilities, hospitals and institutions responsible for the upskilling of nurses, the VReduMED Handbook created in 2026 to ensure that those care experts are enabled to find all information needed to introduce VR technology in their teaching.

Care Education Forum

Through the implementation of a forum for care educators, experts and practitioners have the opportunity to help innovate practice-oriented VR teaching and learning. The VReduMED Care Education Forum aims to address the practical challenges of providing hands-on, quality nursing education by relying on theoretical knowledge and lived experiences of care education lecturers, teachers and trainers.

EEN Matchmaking events

To ensure that the project outcomes are widespread and to identify potential collaboration partners within the EU, the VReduMED consortium is attending EEN matchmaking events.

Sustainability (plan)

To ensure the sustainability of the project, a sustainability plan is available as a guideline.

The VReduMED toolkit and other outcomes presented at the final conference are available for public use to sustain the knowledge transfer of the VReduMED experience and to help initiate and accommodate concrete implementation projects.

6.3.2. Medium Term Measures

This section describes measures aiming at the time after the VReduMED project is completed, to ensure sustainability.

Supporting across border cooperation

Within VReduMED new ways of cooperation have been initiated and maintained in various target groups. Many of these cooperations are carried on beyond the completion of the project, among participants in the MedTech and VR sectors and in the Care Education Forum. At least two project partners from each partner region and their associated partners are continuing their cooperations, sustainably supported by their regional and thematically competent transnational project partners beyond VReduMED project lifetime.

Follow-up projects

Several project concepts for developing VR-based solutions for care education were and will be identified in the VReduMED project and will be continuously supported beyond project lifetime.

It is expected that half of the newly developed VR-based solutions will be taken up or scaled up by care institutions within the first two years after project finalization. On average at least one VR-based solution developed by transnational teams from VReduMED target groups will be sustainably implemented and become inspiring good practice for other innovators.

Availability of VReduMED outcomes

To ensure that the VReduMED toolkit and other outcomes and resources remain available, the VReduMED website is hosted after project completion.

6.3.3. Long Term Measures

Long term measures are targeting governments and network clusters suggesting activities to promote innovation in the field of Virtual Reality in MedTech and Care Education in the long run.

Strengthening transnational networks

As discussed in chapter 5, national as well as transnational collaboration projects need strategic funding strategies and well-established international networks. Therefore, transnational networking activities within S3 network of other initiatives is crucial to look out for and participate in suitable matchmaking activities.

Regional and national funds

To use regional and national funding instruments also for transnational collaboration projects, companies as well as research organizations must keep an eye on funding possibilities.

Staying up to date with technology

As technology in the field of Virtual Reality is evolving very quickly, it is necessary to keep up to date and frequently evaluate new developments and innovation to be able to create innovative solutions.

6.4. Sustainability

To ensure the sustainability of the VReduMED project and the implementation of the project, a sustainability plan prepared in 2026 and listing all concrete measures which will be implemented after the runtime of the VReduMED project.

An updated future version of this Roadmap will refer to this sustainability plan by providing a respective download link.

7. Conclusion

The VReduMED project demonstrates the transformative potential of VR in the MedTech sector, particularly for the training of healthcare professionals. The results underline the transformative potential and the need for a coordinated approach to remove technological, educational and infrastructural barriers. While VR offers significant benefits - such as safe training environments and the ability to simulate complex scenarios - it also requires careful implementation to be effective.

To this end, the VReduMED Roadmap at hand provides a toolset for relevant specific target groups, to support them in the process of deploying VR.

For public authorities dealing with caregiving, the outcomes of VReduMED may serve as a valuable collection of information and recommendations, to support decision makers in their work.

For MedTech companies wanting to start or expand their activities in that sector, the Roadmap can help to better understand specific requirements and circumstances, such as concrete demands of various user groups involved.

Suppliers of VR solutions can benefit from this Technology Roadmap along the development path, from identifying proper markets and concrete demands, developing novel solutions to finally rolling them out on the care sector.

For cluster initiatives and business agencies, both on regional and national levels, this Roadmap may serve as a guide supporting the launch of dedicated projects, developing and rolling out a plan to utilize VR in care education, adapted to local needs. Also, there are proposals on how to identify partners for transnational cooperation within the framework of the European Commission.

Finally, for institutions in caregiving education and vocational training, the Roadmap provides basic technical information related to VR and proposes concrete measures to be carried out in that respect.

To sum up, VReduMED identified potential pitfalls, challenges and structural gaps that might occur along the path of deploying VR in caregiving education, from the perspectives of different stakeholder groups. For typical scenarios and related issues in that context, the VReduMED Roadmap provides insights, best practice examples, recommendations, and tools to address the challenges and conduct successful implementation projects.

The overall vision of VReduMED, which the Roadmap is aimed to support, is that Central Europe becomes a leader in the use of VR for healthcare training. This will not only improve the quality of care but also position the region as a global hub for innovative MedTech solutions. The Roadmap at hand, established in the framework of VReduMED, will serve as a guide to achieve these goals and encourage both public and private institutions to invest in VR and use it as an important educational tool in the healthcare sector.

Appendix: Link List

Entries are ordered as appearing in the document.

- Virtual and Augmented Reality Industrial Coalition Strategic Paper
  https://www.oficinamediaespana.eu/images/media_europa/StrategicpaperVRARCoalition.pdf
- Interreg Central Europe
  https://www.interreg-central.eu/
- VReduMED partnership
  https://www.vredumed.eu/project-partners/
- Technology Roadmap
  https://www.iea.org/reports/technology-roadmap-a-guide-to-development-and-implementation
- VReduMED website
  https://www.vredumed.eu
- Interreg central Europe website
  https://www.interreg-central.eu/projects/vredumed
- guide to development and implementation of energy technology roadmaps
  https://www.iea.org/reports/technology-roadmap-a-guide-to-development-and-implementation
- VReduNET Project
  https://vredunet.eu/
- Good practice catalogue
  www.interreg-central.eu/wp-content/uploads/2024/07/VReduMED-Good-Practise-Examples-2.pdf
- Round table events
  https://www.vredumed.eu/roundtables
- VReduMED Magazine
  https://www.vredumed.eu/vredumed-magazine
- VReduMED Care Education Forum
  https://www.vredumed.eu/care-education-forum
- online registration form
  https://www.vredumed.eu/care-education-forum
- LinkedIn
  https://www.linkedin.com/company/100073148
- Facebook
  https://www.facebook.com/VReduMED
- Smart Specialization a Possible Solution to the New Global Challenges
  https://www.sciencedirect.com/science/article/pii/S221256711300124X
- three pillars
  https://ec.europa.eu/regional_policy/policy/communities-and-networks/s3-community-of-practice/about_en

- Community of Practice (CoP)
  https://ec.europa.eu/regional_policy/policy/communities-and-networks/s3-community-of-practice/community_of_practice_en
- S3 CoP Observatory
  https://ec.europa.eu/regional_policy/assets/s3-observatory/index_en.html
- S3-4AlpClusters project
  https://www.alpine-space.eu/project/s3-4alpclusters
- Kohesio
  https://kohesio.ec.europa.eu/en/projects
- European Cluster Collaboration Platform
  https://reporting.clustercollaboration.eu/all
- Dominique Foray, Martin Eichler, Michael Keller; in: Review of Evolutionary Political Economy (2021)
  https://link.springer.com/article/10.1007/s43253-020-00026-z
- Method of “project mapping” example

  https://link.springer.com/article/10.1007/s43253-020-00026-z
- S3-Innovation Model (DOI:10.13140/RG.2.2.34276.63366)

  https://www.researchgate.net/publication/329359898_S3_Innovation_Model
- S3-4AlpineClusters
  https://www.alpine-space.eu/project/s3-4alpclusters
- S3 CoP Observatory
  https://ec.europa.eu/regional_policy/assets/s3-observatory/index_en.html
- EUREKA
  https://eurekanetwork.org
- ICT for the Future
  https://www.ffg.at/sites/default/files/allgemeine_downloads/thematische programme/IKT/iktdz_e.pdf
- Virtual Worlds and Digital Solutions for Health
  https://www.ffg.at/virtuelle-Welten-Gesundheit-2024
- Business- and Research cooperation promotion
  https://www.land-oberoesterreich.gv.at/526010.htm
- VReduMED survey and mapping outcomes
  https://www.vredumed.eu/mapping-surveys
- VReduMED Roundtables
  https://www.vredumed.eu/roundtables
- VReduMED Workshops
  https://www.vredumed.eu/workshops
- VReduMED Magazine
  https://www.vredumed.eu/vredumed-magazine
- VReduMED stakeholder involvement activities
  https://www.vredumed.eu/events-news

- VReduMED hybrid mid-term event
  https://www.vredumed.eu/event/vredumed-mid-term-event-gyor-hungary
- Train-the-trainer programme
  https://www.vredumed.eu/train-the-trainer-programme
- VReduMED lab programme
  https://www.vredumed.eu/vr-lab-programme
- VR application prototypes
  https://www.vredumed.eu/vr-application-prototypes
- VReduMED pilot actions
  https://www.vredumed.eu/pilot-actions
- VReduMED Handbook
  https://www.vredumed.eu/vredumed-handbook
- VReduMED Care Education Forum
  https://www.vredumed.eu/care-education-forum