

Virtual Reality for Supporting Knowledge Sharing: An Exercise of Technology Assessment

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Abstract: Knowledge sharing is an important process in knowledge management to foster collaboration. For its effective management, it is often suggested to use the support of adequate technologies. Virtual reality (VR) is a promising technology whose application in business increasingly attracts attention in activities, such as business meetings or training, where participants need to share knowledge in a complex context with communicational, social, and management implications. Due to the immersive capabilities, VR may provide new ways of sharing knowledge. However, due to the novelty of this technology, research is needed to evaluate its potential and drawbacks. This study aims to contribute to further understanding of whether and how the introduction of VR in organizations can favour knowledge sharing and collaboration between employees and to evaluate its potential, challenges, and prospects. It is based on a qualitative exercise of technology assessment based on two approaches: technology monitoring and collection of expert opinions using interviews with experts in organisations specialised in VR. Our analysis shows that VR has the potential to break barriers of time and space that may hinder effective human interactions. It can simplify the sharing of notions, data, and, more generally, knowledge, and allow people to connect and communicate as active protagonists. However, adopting VR may require organisational changes and has some limitations. In addition, appropriate knowledge-sharing models for VR applications still need to be developed. Consequently, our paper argues that although much is possible today with VR, further developments are still needed for this technology to reach complete maturity.

Keywords: Virtual reality, Knowledge sharing, Technology assessment

1. Introduction

Knowledge sharing (KS) is a primary process in Knowledge Management (Edwards, 2016) and key to fostering collaboration and knowledge creation. However, KS can be complicated (Liebowitz and Yan, 2004), and consequently, for effective knowledge sharing, it is often suggested to use the support of adequate technologies (Mueller et al., 2011; Newell et al., 2009). Virtual reality (VR) is a promising technology whose application in business increasingly attracts attention (Wohlgemant et al., 2020), especially in situations like business meetings, where participants need to share knowledge in a complex context, which has communicational, social, and management implications (Standaert et al., 2021).

Virtual Reality (VR) provides users with a 3-dimensional, 360-degree computer-generated virtual environment (Kandaurova & Lee, 2019). VR can be seen as a knowledge-sharing support system due to the immersive capabilities offered to its users (Campbell et al., 2019). However, due to the novelty of this technology, which has not yet reached its maturity in business, the application of VR for knowledge sharing still requires research to evaluate its potential and current drawbacks. Therefore, our study aims to understand whether and how the introduction of virtual reality in organizations can favour knowledge sharing and collaboration between employees and to evaluate its potential, challenges, and prospects. It is based on a qualitative exercise of technology assessment (Braun, 1998) based on two approaches: technology monitoring and a collection of expert opinions (Porter, 2011) using interviews of experts working in organizations specializing in VR.

Our study finds, on the one hand, that VR provides benefits as human interactions are supported despite differences in time and space. VR can simplify the data and knowledge sharing, as it allows people to connect and communicate as active protagonists in a virtual space. On the other hand, VR use requires organizational changes and has some limitations. Appropriate knowledge-sharing models for VR applications still need to be developed. Although VR provides new opportunities for KS, further developments are still needed to reach complete maturity in technical and organizational terms to enable successful knowledge sharing in the virtual world.

2. Methodology

This study is based on the technology assessment methodologies described in Porter (2011) and Braun (1998). In particular, it combines two approaches: Technology monitoring and Expert opinion. Technology monitoring consists of a systematic collection, from the specialized literature, of information about the technology and the analysis of its state-of-the-art (i.e., technical features, functioning, main components, and configurations), likely advancements, and future research directions, actual or potential business applications, and its implications for manufacturing and marketing. This process can be divided into steps which, in the case of our study, were defined as follows:

- Set objects and goals of the monitoring (in our case, an analysis of virtual reality, its applications to knowledge-sharing situations in business, its potential pros and cons, and its likely future)
- Select sources of information (mainly scientific journals and books, technical papers, and specialised websites)
- Collect documents and perform a systematic analysis
- Summarise information

The most critical issues are the selection of documents and the analysis of information. In our case, a cross-analysis was performed to seek confirmation between independent sources. The second point was that VR is not often explicitly considered a KS application. Therefore, it was necessary to derive information employing an analysis of its current applications, especially in activities (namely, business meetings and training) where VR can support KS.

The second approach - Expert opinion - is based on the assumption that experts who work in a field can have important elements and new perspectives, especially on the potential and problems of research and on the current applications of technology, information that may be difficult to find in the literature. The method is based on: a) a selection of one or more experts to consult; b) interviews or other methods of collection of information; c) recording, transcription, and data analysis; d) comparisons and synthesis. A problem with this method is that the experts can mix objective data with their personal opinions, so it may be important to contact more experts and conduct a cross-analysis of the collected information. In our case, we selected three technical experts of VR working in three different companies (one in Italy and two in Denmark). Interviews with these experts were conducted based on a set of open questions regarding a) the possible business applications of VR; b) the potential for knowledge sharing in organizations; c) the possible barriers to adoption; d) the impact on humans; and e) the prospects of this technology. Specifically, in the questions, the interviewees were asked to confirm or discuss the main points learned through technology monitoring. The collection of information was conducted in the second half of 2022.

In short, the collection and analysis of data were conducted by adopting the model described in figure 1. First, a technology monitoring was conducted to collect and analyse the available documentary data about the current configurations of the technology, the prospective business applications, the possible trends of market and research, the possible issues and practical problems, etc. This analysis was especially conducted with reference to the application of VR for knowledge sharing, by using the definitions and notions derived from the KM literature. After that, expert opinions were conducted to seek confirmation of what was found in the literature and documentary sources. A set of questions to guide expert interviews were defined, and an analysis of the expert views was conducted.

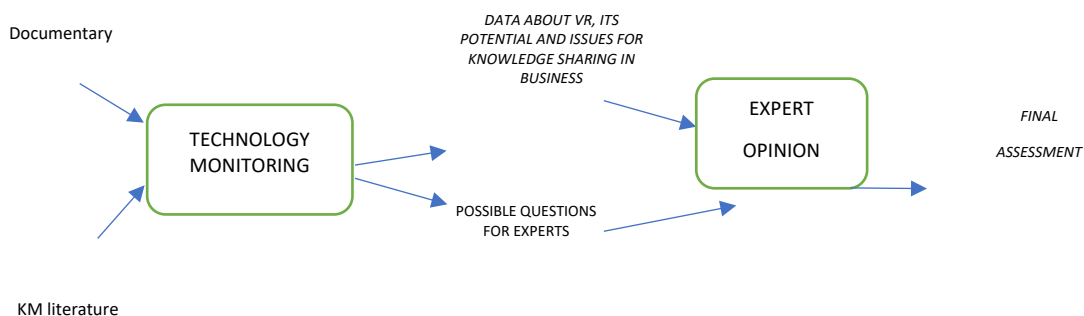


Figure 1: Analytical Framework

Regarding how the analysis was conducted, some further clarifications can be added. The preliminary analysis of the technology by means of the monitoring analysis revealed that VR is a very wide area that includes several applications in different contexts. Being apparent that its use and the specific technical configurations that are implemented can be different and context-dependant, the analysis then focused more specifically on the most promising application areas for business and, especially, those where knowledge sharing processes can be more impacted. As will be illustrated below, the application areas where the use of VR was investigated are internal business training and internal meetings.

In the following sections, we summarise the main findings of Technology monitoring that mainly focused on a description of the technology and its potential for KS (sections 3 and 4), and later of Expert opinion, which primarily focused on business applications, to find confirmation about pros and cons of VR (section 5) as derived from technology monitoring. Section 5 compares the results obtained by the technology monitoring analysis with the information collected from experts.

3. Virtual Reality: State of the art and Prospects

In this section, we describe the state-of-the-art and prospects of VR. We will also frame the notion of VR in the broader picture of the so-called "immersive technologies".

Technologies that allow to extend or create an environment with a high degree of involvement, thanks to a greater sensory isolation, are named immersive virtual reality. This immersive environment is created through interactive interfaces, which reduce the boundary between the physical world and the virtual environment, thus generating a multisensory virtual experience for the user.

This experience can be achieved using different devices, some of which make it possible to extend the physical space by adding virtual elements. Other kinds of technologies transfer the user to another environment with a fully immersive experience that allows forgetting about the physical and material environment in which the user is physically located. Here the concepts of VR and Mixed Reality (MR) emerge. These technologically advanced realities are identified with the all-encompassing term of extended reality (XR) that, according to Fast-Berglund et al. (2018), "refers to all real and virtual combined environments and human-machine interactions generated by computer technology and wearables".

The concepts of AR (Augmented Reality) and AV (Augmented virtuality) are positioned in the middle between the completely real and completely virtual environments. All technologies that "allow the overlay, in real-time, of images, markers or information generated virtually, on images of the real world" are identified under the term AR (Telefónica Fundación, 2011). On the other hand, the term Augmented Virtuality (AV) is less used. According to Valente et al. (2016) it consists "of a virtual world augmented with the mapping of an image or video from the real world in virtual objects".

The two terms combined fall into the broader concept of Mixed Reality (MR), the environment where the physical world and elements of the virtual context are displayed together on a single screen. Therefore, it is appropriate to refer to AR and AV as technologies that offer the opportunity to enhance the real environment with virtual information and elements.

The focus of our study is especially on VR, whose special and distinctive characteristic is that it creates a totally virtual space where the user is completely immersed and that is accessible only through the use of a special headset and, if necessary and possible, other sensorial applications (e.g., gloves) and a high-performance software (Wohlgenannt et al., 2020). Although there is sometimes a variegated use of the adjective "immersive", in this study we will use the term VR to specifically consider those applications that engage the user in a total or almost total sensorial experience. In these terms, VR represents a more "immersive" technology compared to other categories like AR or AV applications. To perform effective immersive simulations, the headset becomes one of the critical elements of a VR system. A basic version of a technology tool like the head-mounted display (HMD) was already introduced in the 1960s, but several barriers limited its adoption. In recent years, the devices have become more affordable and performant, and VR has been again put at the center of attention. Its market is growing especially in the areas of entertainment and gaming. Still, there are now many other sectors of employment, with a wide variety of applications, for instance, healthcare, education, or tourism (Wohlgenannt et al., 2020).

VR is therefore seen as a medium in which users are involved with their entire body and respond to perceptions of that environment as if they were real. A computer feeds a digital description of an environment, and several visual, tactile, and auditory equipment provide a high level of realism and, consequently, immersion. The

tracking tools used for virtual experience ensure that the displayed images are updated according to the orientation of the head and possibly other body parts with respect to the synthetic environment. The quality of a virtual reality experience, defined as a medium, depends on how the user perceives the virtual world.

In the virtual experience, the user's perception of the digital environment is fundamental. For this reason, sensory displays or VR system output instruments are essential because they stimulate the human senses. These devices feature different characteristics and, in particular, are classified as visual, haptic, and aural displays. The input devices control movements and actions performed by the user and monitor them during the virtual world experience. This allows the participant to be immersed in that environment and to interact with the digital simulations. In addition, user monitoring makes rendering activity possible.

The user can send information to the system both actively and passively. The active method requires physical tools such as keyboards or joysticks that are activated by the user's action; on the other hand, passive inputs include body and position control tasks detected by the monitoring system. There is also the possibility of carrying out a worldwide monitoring where the information of the physical environment mixes with the virtual one, for example, data from meteorological stations.

The performance of the technical system is critical. For the users to perceive that they are totally immersed in a virtual environment, the interaction with their sensorial system must be effective. Telepresence is defined as "the experience of presence in an environment by means of a medium" (Steuer, 1992). As shown in figure 2, to ensure that, the technology must have high performance as regards both the vivid reproduction of the simulated environment and the interactivity of the users with the digital objects.

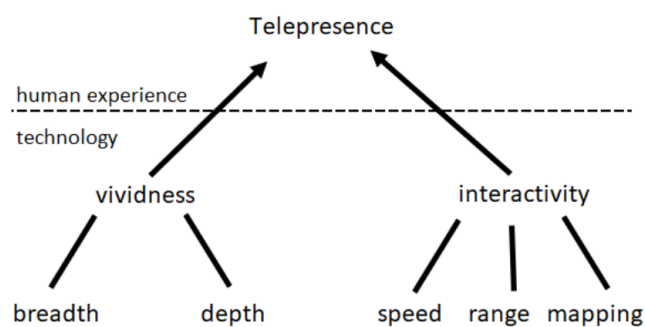


Figure 2: Dimensions of Effective Telepresence (Adapted from Steuer, 1992)

In a VR system, the most relevant tracking device is the position sensor that detects the user's orientation in the digital world through head and hand tracking. In position sensors, three basic parameters are to consider: the speed and accuracy of the detected orientation, the footprint, and the interfering means. Finding systems that ensure optimal conditions in each feature is difficult, so designers must seek compromises based on using the virtual system. Another critical device is the head-mounted display. Although the recent versions of this device are lighter and more comfortable than in the past, these objects are still bulky and have some limitations.

4. Knowledge Sharing and VR Applications

In this section, we summarize the technology monitoring results explicitly focused on using virtual reality for Knowledge sharing. KS is one of the most important processes in knowledge management, and this term is one of the most cited in the literature (Bolisani and Scarso, 2019). In general terms, it can be defined as the activities by which two or more people share a piece of knowledge with or without the support of information technology. Actually, it can involve a combination of different processes: an exchange or transfer of pieces of knowledge and information from someone to someone else, a process by which elements of knowledge become available and easily usable to all interested people in an organization, a process of mutual learning by all parties involved where people learn together and learn from one another, a process of creation and use of a common language and reference so that people can more easily, interact and communicate, etc. Therefore, it is different from a pure "knowledge transfer" (Edwards, 2016), where one person simply provides a piece of knowledge to somebody else, for example, through a document: sharing involves more active participation of both "giver" and "taker" and, actually, the "giver" of knowledge also receives feedback from the "taker" and, in turn, learns from this interaction. In addition, KS necessarily involves human beings and is, therefore, influenced by their attitude to interact, disclose their knowledge, be open to others, change their perspectives, etc. In other words, KS is

substantially a social process and a way for the organization to learn collectively (Cantamessa and Montagna, 2016).

The KM literature has underlined that several factors influence it. The first is a “technical” dimension. Following Nonaka and Tagueuchi’s (1996) model of knowledge conversion, to effectively share knowledge contents a proper conversion between their formats is needed. Therefore, every single case may require different modalities of conversion. A second important dimension is related to the social context (Asrar-ul-Haq and Anwar, 2016), which is influenced both by the personal attitudes of individuals and by the organizational settings. An important factor is mutual trust between knowledge sharers, which may affect the willingness to share knowledge and also the effectiveness of the process. Culture - i.e., the set of values of individuals in the context where knowledge sharing occurs - can also influence KS and can stimulate or reduce the motivation of individuals. Culture is related to people, but an organization can favour open-mindedness towards different positions and viewpoints, facilitating KS. Finally, the active presence of a “leader” or facilitator of KS can also be an important support.

The KM literature has often studied the technologies that can support KM and KS (Mueller et al., 2011; Newell et al. 2009), and attempts have been made to assess the effectiveness of different technology supports. The literature especially emphasizes two applications where VR can be particularly important in relation to KS: meetings and training. Meetings are a common method used in companies for several purposes and are especially important when there is something to discuss or to decide.

In meetings, people need to share elements of knowledge and, possibly, should actively participate with their contribution to the creation of “collective” knowledge in the group. The objectives of a business meeting can be multiple (Griffin, 2020; Standaert et al., 2021) and include not only exchanging information and making decisions but also communicating sentiments or building relationships, which recalls psychological aspects.



Figure 3: Wearing Head-Mounted Displays (Left) to Meet Colleagues in VR for Knowledge Sharing (Right)

Information and communication technologies can support these more or less effectively. Campbell et al. (2019) discuss that VR functions can reproduce the context where meetings take place with all the sensorial effects so that participants can feel like they are in a face-to-face meeting, but at the same time, the burden of hierarchies and inequalities can be reduced by means of the use of avatars that encourage participants to express their opinions more freely (Fromm, 2020). For example, in a brainstorming meeting, VR could lead to higher and more active participation. In a social event facilitated by VR, participants as avatars walk around freely in the virtual space and share knowledge with others (Figure 3) - which they may feel to be more lively and interactive than video conferences (Kirchner and Nordin Forsberg, 2021).

In training, knowledge must not simply pass from instructors to learners because the latter must be actively involved in the learning process to construct their own knowledge, and the former must take into account the feedback coming from learners and must adapt to their needs; in short, there is a sharing of knowledge. Some studies claim that the use of VR can have several benefits (Xie et al., 2021) and especially, due to high cost or complexity, training in a physical environment would be difficult (Martirosov and Kopeček, 2021) and simulations of real-life cases can be more easily reproduced without risk. This can also result in a better understanding of the specific instructions whose knowledge trainers are sharing with learners with a high realism (Martirosov and Kopeček, 2017). The use of VR environments has some potential benefits. The first is to overcome the lack of qualified instructors: once a virtual environment is set up based on the directions of a skilled instructor, simulations can be run as many times as desired. This is a special form of KS between the instructor (that sets up the VR simulation) and the current and future trainees (that will use it).

The second potential benefit is that a deep immersion of trainees is ensured, and they are therefore not easily distracted. In addition, VR training can lead to a real engagement of trainees even in emotional terms, which is useful, especially in simulated situations where emotions can influence problem-solving and decision-making processes (Martirosov and Kopeček, 2017). Finally, VR allows the creation of contexts where errors are tolerated, producing lower stress levels in trainees. Training can help new employees to feel more included in the workplace and become familiar with their new job and equipment as quickly as possible. Also, by observing the reactions of trainers in the VR environment, instructors can interact with learners in the simulated environment in real-time, and learn more about the training process, its effectiveness, and the problems that may arise.

The analysis of the available studies also made it possible to underline some of the main obstacles of VR for KS. Some are technical. Even though there have been important improvements in technical performance, VR devices still have limitations (Garret et al., 2018) especially because even a minimal imperfection in the VR simulation can reduce its usability and effectiveness and can have negative effects like motion sickness (Jalo et al., 2020). Another point is related to how much the user feels comfortable with this technology (Jalo et al., 2020). Although it may be argued that the young generations, more familiar with digitally simulated gaming, can easily accept this technology, likely, companies willing to use this technology must also provide training courses to employees.

Another key issue is the cost. Despite the decreasing cost, the investments needed for the technology are still significant, especially if many users are involved at the same time. The necessity of highly performant devices and graphic simulations and the related cost can still be a barrier to adoption (Garret et al., 2018)

5. Expert Opinion: Findings and Comparison with the Elements Found in Technology Monitoring

In this section, we summarise the results of the collection and analysis of expert opinions. The main purpose was to find confirmation regarding the points that had emerged in the technology monitoring analysis. We will refer to the three experts as A, B and C for anonymity reasons.

The experts were identified by contacting 3 companies selected through names reported in the “Welp Magazine” repository (see <https://welpmagazine.com>). For reasons of convenience, companies in Denmark and in Italy, among those most actively engaged in VR research and commercialization (but not merely on videogames), were selected based on their performance in terms of innovation, growth, social impact and management capabilities. After sending invitations to participate in the investigation, those which replied were finally selected, and namely two based in Denmark and one in Italy. In these companies, some key experts were identified and directly contacted for interviews, and namely: for the first company, the current CEO and founder who is an expert in developing “virtual worlds”; for the second company, a sales manager and expert in design, communications, and marketing projects; for the third company, a developer of customized VR solutions and expert in immersive audio and virtual productions. The selected experts have different roles in their companies; therefore they cover various aspects and perspectives on the investigated issues. A semi-structured interview was conducted where respondents were asked to provide information about: their company, its activity and products (to better frame and understand the information they provide); the current use of VR; their opinion about VR and its applications in business; their idea of VR as a tool for knowledge sharing; their opinion about how easy it can be for companies to implement and use of VR, the necessary training, and all the related issues; the current feedbacks and feelings they have regarding their market (i.e., other companies using VR and how they are experimenting and using it); their opinion about the current and future challenges of VR in business, related to technical, management, or market issues; the potential impact on humans; the expectations regarding future demand, and the business applications with more potential.

The interviews were conducted in person (for the Danish experts) or online (for the Italian expert) in the second semester of 2022. The collected answers were then analysed thoroughly by means of a discourse analysis, and the main aspects were compared with the information collected by means of the technology monitoring analysis.

5.1 Benefits of VR for KS

According to the information collected via technology monitoring, it is reported that VR, due to its media richness and synchronous functioning, can help to overcome some barriers that hinder KS. In addition, it can help favor knowledge transfer and an engaging learning experience. The experts confirmed these points at least partially.

The companies where the experts work as technology developers work, have their business in the development of immersive solutions, and VR consulting. However, the consulted experts admit that their organizations are not using VR in their own processes, as it is mainly used as a demonstration prototype for customers. They do confirm that, based on their experience, VR can bring many potential benefits especially due to the ability to provide the user with a realistic and emotional experience. Moreover, VR can reduce costs, time, and space barriers for KS activities requiring face-to-face meetings.

For example, as affirmed by A and B, VR allows recreating scenarios to play role games which is very effective in training, even reproducing dangerous situations, for instance, how to set a fire. This would be expensive and risky if performed physically, but VR, due to the immersive conditions, can effectively replicate decision-making under emotional stress and allow effective learning while avoiding risks. According to C, VR also makes it possible to overcome time barriers by presenting the users something that is not yet existing (for example, simulating interactions in a future situation) or even reducing some social challenges (e.g.: virtual experience can be proposed even to people with physical disabilities). In substance, VR can even extend the opportunities for KS in organizations.

5.2 Business Applications

The experts also confirm that VR's characteristics apply to different use cases and business fields. This is in line with recent reports affirming that thanks to the big investments by major companies, VR is finding more and more space (Wohlgenannt et al., 2020).

More specifically, regarding business meetings, the interviewed experts confirm that, more than other existing technologies, VR is effective in covering certain moments of human interactions, so it can be used for some parts of the collaboration process. An interesting point is made by expert A, who noticed that this can still be a conservative view - substantially, a mere transposition of traditional meetings to the virtual world. In other words, the real novelty of VR may emerge when new perspectives or modalities of KS will be implemented with the support of this technology.

Regarding training, according to expert A, there are a number of indicators that show that the use of immersive technologies has a high added value in learning. In fact, all experts confirm what was found in the technology monitoring analysis: immediate and lasting learning is favoured thanks to the learning-by-doing simulated method in an immersive environment, where users become protagonists of the actions, enabling them to familiarise themselves and improve their procedures and tasks. Training is, therefore, an elective field of introduction to VR, especially as regards learning about how to use products, production sites, and for safety instructions. In short, the interviews lead to expectations that VR will continue to significantly impact these business activities.

5.3 Limits and Problems

As analysed in the technology monitoring, there are some challenges to fully introducing VR in business. First, it was underlined that the companies could be held back by the economic expenditure required to purchase the devices. In addition, there may be costs associated with introducing VR related to required organizational changes. Firstly, virtual technologies must be adapted to internal systems. Although he considered VR to be an intuitive technology, Expert C admits that teaching employees how to use the technology properly may be necessary. Also, the complexity of headsets and the problem of motion sickness may not encourage their use. However, the experts pointed out that motion sickness is due to the insufficient quality of some headsets available in the market at a low cost. Probably, this problem will be reduced by improvements in performance.

The interviews also confirmed that some risks of digital technologies - e.g., privacy - are amplified in the virtual context; for example, the issue of fake news and false perceptions is amplified. Moreover, the experts also admitted that immersive technologies might affect users' emotions and psyches. This is still an unexplored area.

According to the experts, predicting what negative aspects can be improved and what limitations will not be easily overcome is difficult. However, there is a lot of research being carried out, and as was declared by experts A and B, over time, many problems with information technologies that were thought to be unresolvable have been overcome later, so the same can happen in the case of VR.

5.4 Future Expectations of Business Impact

The experts affirmed that the spread of VR can significantly impact how we work; and increased requests of working from home have already changed how we interact in business and normal life. This has further increased

the demand for collaborative virtual environments. Although, even for the experts, it is difficult to predict if and when the current limits of VR will be overcome, they all agree that the areas with the greatest potential for development and success are those of collaborative meetings and training.

6. Conclusion

Figure 4 summarises the analysis results and the main points regarding the potential benefits and current limits of VR, especially regarding knowledge sharing. The figure includes the points derived from the technology monitoring and later confirmed through expert interviews.

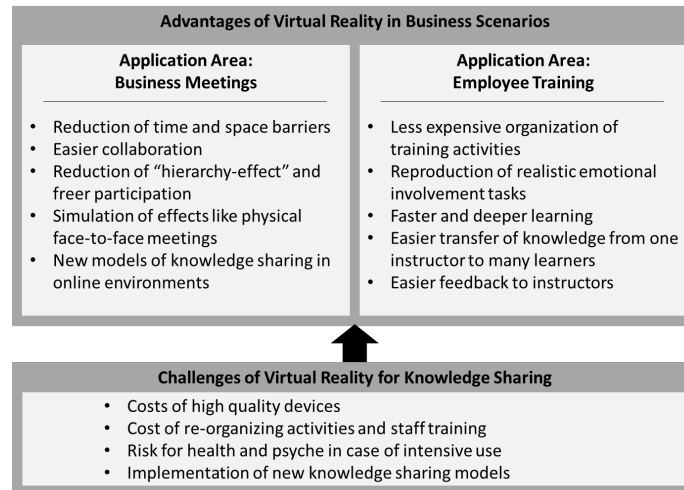


Figure 4: Advantages and Challenges of VR use for Knowledge Sharing in Business Activities

A general comment can be made on the real novelty of VR especially compared to other online communication tools. An important characteristic of VR is its capability to reproduce a context where participants can be involved emotionally and with all their senses. In other words, it is the closest possible reproduction of a real-life experience but in a simulated environment.

For this reason, knowledge sharing can be supported in entirely new ways compared to traditional technologies used in both meetings and training - such as, e.g., video conferencing. As is well known, knowledge sharing using human interactions can require, to be effective, a “total involvement” or sharers. Therefore, VR can be a really new approach.

It must, however, be noted that the technology still has some limitations, especially as regards its cost (at least, for high-quality devices), the organization of the activities (that can imply the adoption of new models for knowledge sharing), and the familiarity of use by the staff (which may be laggard to adopt the innovation). For this, there is still work to be done regarding technological advancements and managerial modifications. There is also an interesting implication for KM research: VR and immersive technologies can show new ways and processes of knowledge sharing and can need new interpretative models to understand how these processes can take place.

This study has some limitations. First, the approach used to collect and analyze data, although it was based on popular methods of technology assessment, is qualitative. Second, the selection of experts was subjective. A larger sample can be used, and other techniques (for example, a Delphi analysis) may be used. In any case, it is believed that the study still provides a preliminary picture of an important issue and can provide inspiration for further research.

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