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Immersive Onboarding: Designing a Training Framework for Effective Virtual Reality Integration in Product Development

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Abstract

Virtual Reality (VR) is increasingly recognized as a valuable tool in product development. To effectively integrate VR into the product development process, companies need skilled personnel, modifications to existing workflows, and robust digital infrastructure. These elements are crucial for preparing the enterprise for VR technology and enhancing its acceptance among team members. This paper provides guidelines for designing a structured and continuously updated training framework, informed by retrospective and incremental measurements, to develop employee skills and ensure the company is well-positioned to leverage VR effectively.

Keywords: Virtual Reality; product development; Training Framework; Digital Skills; Employee Preparation; VR Integration

1. Motivation

In the context of integrating virtual reality (VR) into product development, the primary challenge is to ensure that employees are receptive to the implementation of this technology. The acceptance of working with such novel technology is contingent upon employee satisfaction and their capacity to utilize the technology in question [1]. The implementation of effective training programs for employees has been demonstrated to enhance job satisfaction [2] which in turn fosters greater creativity in the workplace [3]. According to the Technology Acceptance Model (TAM) proposed by [33], two key factors influence user acceptance of new technology: perceived usefulness and perceived ease of use. Perceived usefulness is the expectation that utilizing a particular technology will improve work efficiency, whereas perceived ease of use suggests that people are more inclined to embrace technology if they consider it simple and intuitive to operate.

In the practical application of VR as a new technology, some challenges emerged during a usability study of VR software at Ostfalia University of Applied Sciences. Two studies were conducted; one with mechanical engineering students and the other with a development team from an industry partner. Several issues were encountered by both teams. In Figure 1, some of these challenges, based on participants' responses, are listed along with the corresponding recommended solutions.

An additional challenge that must be considered when integrating VR into the product development process is the process itself. VR has the potential to support different stages in the product development process, including design reviews [4], ergonomics studies [5], idea generation and initial model drawing [6], and maintenance support [7]. In order to reap the greatest benefits of VR in these phases, it is essential to adapt and, on occasion, restructure the process to ensure that each phase is equipped to handle new tasks in an effective manner.

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In general, during the process of digital transformation and the implementation of new technology into existing processes, a number of challenges are frequently encountered [8] , such as:

- Integrating new technology into existing processes.
- The need to adapt or redesign existing workflows.
- Managing large volumes of generated data.
- Compatibility between new and traditional technologies.

Considering these challenges, ensuring the acceptance of VR as a new technology in the product development process requires addressing them effectively. In practice, this means that VR implementation should not be abrupt; rather, it should be accompanied by comprehensive training to help users become comfortable and proficient with the technology.

Test group	Participant-Identified Challenges	Researcher Observations	Required Improvements
Group 1	"Successful but more practice is necessary."	• Participants needed more time and training to work effectively with the software and hardware. • Responses indicated a need for oriented practice to reach satisfactory performance levels.	Employee Competences
	"This is my first time working with VR. It is difficult; it would have been better with more time."		
	"Orientation was not there, and the task was difficult."		
	"Complex at first; operating with it must be practiced."		
Group 2	"I found the task easy, but operation and verbal description were complex due to a lack of routine use."	• Participants faced challenges related to their familiarity with the task. • Participants found the task mentally challenging initially, reflecting the need for better preparation and understanding. • The distributed team setup highlighted issues with communication and coordination, affecting performance levels and the ability to fully comprehend and execute the task.	Working in Distributed Teams
	"The task was good and comprehensible but did not fully correspond to the knowledge/application area of the test subjects."		
	"It was mentally challenging at the beginning."		
	"Due to several factors, the performance level was not reached."		
Group 2	"Except for the technical difficulties such as 'audio' and the Session shutdown, everything was fine."	• Technical problems, such as Internet disruptions, synchronization issues and communication difficulties.	Technology

Figure 1 Challenges faced using VR in product development

Overall, successfully implementing VR as a new technology in the product development process and ensuring employee acceptance requires comprehensive research and developing solutions in the following key areas:

- Required digital skills for employees.
- Interaction skills for employees in distributed teams.
- Necessary assistance tools.
- Adapting the current product development process.

2. State of art

In recent years, the rapid advancement of new technologies has compelled enterprises to pursue digital transformation [9]. VR offers itself as a new technology in the context of digital transformation. The incorporation of innovative digital technologies in the development process is necessary to harness these advancements effectively [10], highlighting a strategic shift towards integrating advanced technological solutions to enhance sustainability and competitiveness. Adopting innovative technologies requires significant changes or enhancements in current digital skills to achieve the desired level of digital maturity [11]. Digital maturity is defined as the comprehensive set of strategies - involving technology, personnel and infrastructure - that a company must adopt in order to prepare itself for digitalization [12]. Consequently, it is essential for a company to assess its digital maturity level before adopting a new technology [13]. This assessment should be carried out continuously, as it must be aligned with ongoing technological advances in order to achieve the appropriate level of maturity [14]. Therefore a targeted training is crucial for improving and developing the skills of the workforce both personally and professionally [15]. Building the workforce is the most important investment a company makes to ensure sustainability and competitiveness [16].

To develop the essential digital skills for product development in industrial companies, four categories of skills must be considered: personal skills and competencies of the workforce [17], interaction skills for employees in distributed teams [18], digital skills to work with technology [19], and process optimization and adaptation [20]. In the following, each category is examined to identify its weaknesses and strengths in order to develop an appropriate training program.

2.1. Digital skills to work with technology

The term ‘Digital skills to work with technology’ is used to describe the digital competencies that are required by employees in order to utilize digital tools effectively [21]. These skills encompass the ability to operate various digital systems and tools, in this case VR technology. In the context of VR, employees require several specific digital skills. These include proficiency in setting up VR hardware like headsets and controllers. They must also navigate and interact with VR environment and software interface. Critical skills involve manipulating 3D objects within virtual spaces for design reviews and collaborative projects. Effective collaboration in VR requires participating in virtual meetings using avatars, engaging in discussions, and utilizing tools like drawing for creating initial 3D models in ideation process. Additionally, they must analyze data generated from VR interactions and create reports to communicate findings to stakeholders. It is of the utmost importance that each team member possesses these abilities. The attainment of proficiency in these abilities results in cost savings in terms of both time and financial resources, as it reduces the necessity for supplementary training of new personnel. This not only enhances efficiency but also ensures that the team can maintain consistent performance levels without the necessity for new training plans [22].

2.2. Interaction skills for employees in distributed teams

VR is a significant tool for implementing meetings [23], and design reviews [24] between team members in different locations. This leads to teams composed of various cultures and experiences. It is therefore imperative that distributed teams are able to establish and maintain positive social relations in order to ensure their success. Oshri et al posit in [25] that effective social relations foster trust, collaboration, and knowledge sharing, which are critical for team members who cannot interact face-to-face regularly. Such relations help bridge knowledge gaps and facilitate smoother workflow and problem-solving. Furthermore, time zone differences are a critical factor to consider when planning meetings for distributed teams. These differences affect the coordination of

interdependent tasks, complicating project timelines and requiring more robust planning and communication strategies to ensure efficiency and collaboration [26]. This is especially important when two or more teams in different time zones need to conduct a meeting and must find a compromise for a suitable meeting time. One potential solution is the use of asynchronous communication, whereby a team conducts meetings such as design reviews, leaving annotations and notes for the other team to review and interact with at a later stage when they are available. It is imperative that employees receive training on how to conduct this type of meeting and how to leave notes in a clear and understandable format, so others can effectively engage and collaborate asynchronously.

2.3. Required digital assistance tools

The implementation of VR as a new technology necessitates the utilization of dedicated hardware, including computers, controllers and headsets, in conjunction with VR software. The transition from conventional tools and routine work to new methods is challenging [8]. Employees need to use VR tools easily and intentionally in order to accept and enjoy working with them. Mastering these digital tools requires not only personal skills but also a high-quality hardware such as computer and controller. Describing or addressing a design issue in VR differs from the methodology employed in CAD. Employees need to learn how to use specific software tools for different tasks, such as applying functions like cutting, transparency, assembly, and disassembly to accomplish the required work. This ultimately results in a more effective and efficient utilization of VR, thereby optimizing its benefits for the intended purpose.

2.4. Process optimization and adaptation

A primary objective for organizations is to enhance their added value by eliminating waste [27]. In order to identify instances of waste within the product development process, it is necessary to analyze the value streams, examining each step of the process from its inception to its conclusion [28]. The objective is to facilitate a reduction in lead time by optimizing the value stream through the elimination of superfluous steps, waiting periods, rework, multiple quality inspections and other forms of waste [29]. Moreover, in addition to optimizing product development, it is essential to prepare the workforce to adapt to these changes. This will be achieved by ensuring they understand all changes and by involving them in decision-making and optimizing management processes [30].

3. Evaluating Current Enterprise Data

Assessing the current maturity level of these four challenges is essential to identify the necessary improvements. This assessment begins by analysing the overall maturity of the team, based on the enterprise's collected data and the current state of product development. It then offers recommendations for the training and improvements required to address the four previously discussed challenges.

Afterward, a detailed evaluation of the enterprise's current progress is needed. This includes assessing the progress of each team member individually, alongside the overall state of product development. The next step is to create a tailored training program for each team member. After implementing the recommendations and training plans, the results and improvements should be reassessed to ensure all team members have reached the same maturity level, the challenges have been addressed, and any waste and weaknesses in the product development process have been eliminated. If weaknesses persist or further improvements are necessary, a follow-up targeted training program and process should be implemented (see Figure 2).

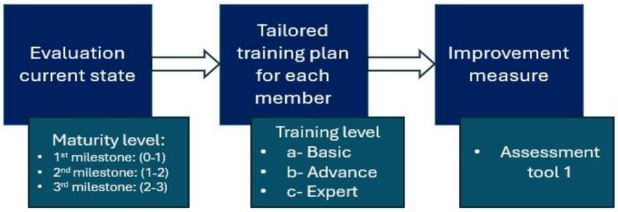

Figure 2 Approach to generating suitable training

Based on the initial maturity level evaluation, it is recommended to design a training program to ensure consistent progress across the team through a pilot project divided into three milestones, each corresponding to an assessed phase. The first milestone aims to raise the maturity level from 0 to 1, the second milestone focuses on advancing from 1 to 2, and the third milestone targets an increase from 2 to 3.

This assessment investigates four maturity levels: the digitalization level of employees, the digitalization level of the company, the degree of virtualization, and process maturity.

3.1. The digitalization level of employees

The first factor is the digital maturity level of employees, which is to be assessed through a survey. The survey evaluates both their motivation to use new technologies and their competencies in using these technologies. To assess employee's readiness for VR technologies, a set of key areas was developed, focusing on two core elements: motivation and competencies. The first set evaluates the willingness and motivation of employees to adopt VR tools:

- Early adopter mentality: gauging openness to innovation and willingness to embrace new technologies.
- Willingness to integrate new technologies: assessing employees' acceptance of new tools, whether they are perceived as complex or easy to use.
- Preference for business travel vs. VR: measuring receptiveness to replacing traditional travel with VR.
- Ability to use new communication tools effectively.
- Willingness to engage in training: especially online programs that enhance digital skills and maturity.

The second set focuses on employee's digital competencies:

- Mastery of 3D CAD software: to evaluate employees' digital design skills.

- Use of communication tools: to gauge their proficiency in digital communication.
- Experience with VR: assessing their ability to operate VR technologies.
- Physical condition considerations: since health restrictions could impact VR usage, such factors may present challenges in implementing VR effectively.

3.2. The digitalization level of the company

The second factor is assessing the digital maturity level of the enterprise. This method involves evaluating seven key areas to compare the company's current state with the targeted state:

- Digitized processes: evaluates the company's readiness to adopt and integrate technology.
- Used digital technologies and solutions: examines whether the company follows trends in new technologies and embraces innovation.
- Planned digital initiatives: assesses how easily the company can adopt new technologies, considering existing budget constraints.
- Future plans for the introduction of new technologies: identifies the company's long-term strategic direction regarding technology adoption.
- Availability of training opportunities for employees: measures the company's commitment to training employees and introducing new technologies.
- Flexibility and adaptability of employees to digital changes: assessed based on the digital maturity level of employees.

3.3. Degree of virtualization

The degree of virtualization is assessed in two reference groups: individuals and the company.

First, the level of virtualization among individuals is evaluated by analyzing the performance of distributed teams using a modified Virtual Team Maturity Model (VTMM) from [18]. The assessment is structured around team processes, including getting to know team members, setting rules and goals, managing information, organizing meetings, encouraging feedback, supporting decision-making, building trust, clearly assigning tasks, and recognizing and appreciating team members. These processes are designed to facilitate the successful transformation of a personal working environment into an efficient remote team.

Second, the level of virtualization within the company reflects the spatial and temporal distance of the locations connected in the project team. The Index of Spatial Distance (IRD) [31] measures the physical distance between locations, which is particularly valuable for calculating the cost savings of eliminating business trips through the use of VR. A higher IRD indicates that it may be more cost-effective to replace business trips with VR, though a more detailed analysis of business trip costs can be found in [32].

On the other hand, the index of temporal distance (IZD) [31] describes the degree of time difference between workplaces. The value of IZD provides insights into the feasibility of conducting a virtual design reviews among temporally distributed teams.

3.4. Process maturity

The fourth factor is assessing the current state of product development. Lead time and process time are critical for calculating the Lean Index, which is used to analyze process performance. A reduction in the Lean Index often occurs due to the waste in product development. Therefore, the goal is to minimize unnecessary waste, such as reducing waiting times and rework through the use of VR.

To identify waste and weaknesses, a detailed process analysis is required. A value stream analysis, based on VDI 2221, is conducted to examine all eight product development phases, from idea generation to the preparation of design and usage specifications. In each phase, lead time and actual processing time for every step are recorded to determine the Lean Index of the process. Additionally, the number of design reviews is assessed to determine whether they occur frequently enough to justify replacement with VR. Finally, the percentage of rework in each phase provides insight into whether the current tools need to be replaced or supported.

4. Concept development

In this chapter, based on company-captured data, a proposed solution is presented to create a structured training concept. This concept consists of three levels: basic, advanced, and expert, to accommodate varying degrees of experience.

The training program is designed specifically for developing digital and personal skills to master VR.

The following sections explain the four key stages of training, grounded in **Experiential Learning Theory (ELT)** from [34]. The concept is designed to help users develop VR-related skills through active learning, incorporating the four stages of ELT: doing, reflecting, conceptualizing, and experimenting.

- Doing: Users engage with VR for the first time, familiarizing themselves with the environment.
- Reflecting: After initial interactions, users evaluate their experience, considering how intuitive or challenging the VR system was.
- Conceptualizing: Based on their reflections, users develop strategies to improve their performance and deepen their understanding of VR interactions.
- Experimenting: Finally, users apply what they have learned by further exploring and testing different VR functions to refine their skills.

4.1. Optimization digital skills

At the beginning, employees need to understand what VR means. A small presentation explaining the meaning of VR, the difference between VR and augmented reality (AR), and how virtual environments are built and operate is necessary. Afterward, a presentation on current and potential future areas of VR application is essential, particularly focusing on its

potential uses within their own departments. Then, a comprehensive explanation of all functions of the VR software, along with the appropriate hardware, is provided. Afterwards, employees begin their first contact with VR through a simple task, allowing them to explore and experience the virtual world. The task is tailored to the intended use of VR. For example, if VR is used in the ideation process, the task will differ from one designed for design review or ergonomics. At a later stage, all of these tasks should be performed at an advanced level at a later stage. Subsequently, employees need to be able to manage and share knowledge across the entire team. They learn also how to integrate different technologies, such as CAD and VR, in the right way.

4.2. Improve working in distributed teams

This section is designed to equip employees with the knowledge and skills required to effectively collaborate in distributed teams. It encompasses an understanding of the various factors that influence team dynamics, including physical and temporal distance, cultural differences, and the unique challenges posed by digital communication. Temporal distance often leads to asynchronous meetings within teams. It is therefore necessary for employees to learn how to complete their tasks independently and to ensure that the progress made is clearly communicated to other team members who were unable to attend the meetings. This will be achieved through annotations or creating assemblies for constructed parts. Additionally, understanding various cultures and finding compromises in case of conflicts due to cultural and experience differences is essential.

4.3. Prepare suitable digital tools

In this section, it is essential to ensure that all necessary and appropriate tools are available. In this context, VR tools refer not only to hardware but also to the integration of information, operations, and resources across all relevant departments. There is a need to clarify or control the design process for production or external customers. The hardware requirements for the development team differ from those of other stakeholders. Additionally, it is important to explain the potential risks associated with digital technologies. Employees learn also how to install the required programs, how to troubleshoot when necessary and how to use the software features correctly. Furthermore, big data is generated through VR and must be available to other departments. This data needs to be accurate and securely stored.

4.4. Optimizing the development process

This section is organized into two parts: the first part addresses the preparation of employees for the implementation of the newly restructured process, while the second part discusses potential restructuring and modifications within the product development phase. In the first part, for employees, an introduction to the structure of processes and sub-processes in product development, process analysis, and value stream analysis is essential to identify potential waste. Additionally, the construction teams should understand not only how to use and review CAD designs in VR but also how to design concepts specifically for VR. For example, it is essential to clearly name all parts of the designed concepts, as this is necessary for assembly function as well as for searching in the parts tree in VR software. Furthermore, teams must be able to document the data generated from VR and understand how to reuse it. In addition, changes in the process must be considered. In particular, when the team uses VR in the ideation phase instead of drawing on paper, these VR-constructed models do not need to be further developed in 3D software to define their features or requirements. As a result of this integration and adaptation in product development, one phase of the process can be combined with another or eliminated altogether. Additionally, the new product lifecycle is now shorter, and the team must take this into account when managing new orders or submitting timelines for completed projects.

In the second part, in addition to the lean index, which provides valuable insights into process performance, several critical factors must be considered in the product development process. One such factor is the integration of 3D CAD systems, as VR offers significant advantages in enhancing traditional 3D design processes. Specifically, 2D designs hold limited relevance in the context of VR applications. Consequently, it is now recommended to replace 2D designs with immersive 3D models in certain phases, such as ideation and design reviews. This shift necessitates changes in the brainstorming process and the manner in which design reviews are conducted. For instance, phases such as ideation, design review, and prototyping have the potential to be more closely integrated into a single phase, as 3D digital prototypes are now available earlier in the process. This enables testing of functionality and requirements before producing physical prototypes and undertaking iterative prototyping processes. Adapting to this change requires not only learning and understanding the new processes but also coordinating with other departments, such as production, to ensure alignment. Additionally, the time and cost savings achieved through this shift could be reinvested into other projects, which may necessitate adjustments in employee allocation and procedures. Another key factor is the reduction in business trips, which necessitates new approaches for information exchange among teams and departments, as well as decision-making processes in a remote or virtual environment instead of relying on physical presence.

An additional consideration is, while the focus here is on learning VR and using it effectively in product development, once VR is fully understood and utilized, it is also serves as a training tool for onboarding new employees, particularly for scenarios such as maintenance or ergonomic tests.

5. Conclusion

To use VR efficiently, the recommended maturity level is 3 (equivalent to 100%), and all four categories should reach this level to be fully ready for VR implementation (see Figure 3). This means all team members must be on the same level to be ready and able to attend the next step. This implies that some members may already be at level two and must wait for other team members at a lower level so they can attend together in

the next phase. Consequently, the lower the initial maturity level, the more training is required, which, in turn, extends the duration of the pilot project. Afterwards, once all team members are at the highest level, a practical implementation of VR is able to be conducted in selected areas. After six months, a new assessment should be conducted to evaluate whether the return on investment has been realized and to determine if additional procedures are necessary. This assessment should also explore other potential applications of VR. Given that integration into new areas does not require further training, it may yield additional benefits.

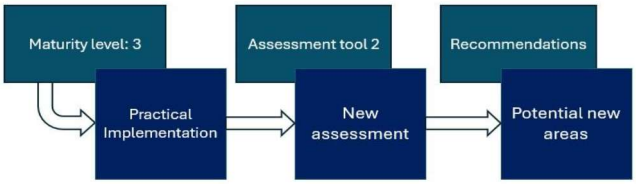

Figure 3 Approach to explore the benefits

Assessment Tool-1 and -2 are designed to capture relevant company data pertaining to the integration of VR in product development. These tools provide insights into the current state of the organization, which are used to formulate recommendations for the effective and seamless implementation of VR in product development. The resulting recommendations will outline procedures for required customizations in the product development, as well as tailored training programs for the team.

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