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The Impact of Gamification on Corporate Extended Reality Training

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Abstract

The digital transformation of the modern workplace has meant that people must constantly acquire new skills and deepen their knowledge to remain competitive. This poses a problem for companies, as they need to find effective ways to provide their employees with the latest training and knowledge that prompt them to increase their investment in technology and employee training programs. One strategy that has received attention as a possible solution is the use of gamification in corporate training. Gamification can have a positive impact on corporate training in a variety of contexts due to its ability to foster engagement and motivation. Integrating immersive technology, particularly extended reality (XR), with gamification strategies may provide employees with a more immersive and engaging learning experience. Despite its potential, the impact of gamification on corporate XR training has yet to be fully explored. Establishing an accurate and comprehensive definition of XR is challenging due to the rapid and continuous evolution of the underlying technology. Furthermore, since XR is multifaceted and complex, the concept of XR specifically related to training presents an additional challenge.

A comprehensive analysis of XR leads to the development of a set of characterizations and concepts, which serve to classify and define extended reality training, offering a definitive and enduring definition.

To assess the impact of gamification on corporate XR training, an evaluation of the effectiveness of hard and soft skills training using virtual reality (VR) was performed. Three separate studies were conducted to collect comprehensive data and analyze the impact of gamification on the effectiveness and acceptance of virtual reality training. The first study focused on an assembly task, while the other two studies focused on VR speech training.

In the first study, the potential of VR for training was evaluated using an assembly task, with a focus on integrating gamification to increase the effectiveness of hard skills training. A study was conducted in which participants were randomly assigned to either a gamified or non-gamified version of the same VR training, and their performance was compared based on the time taken and errors made during the training session. The results of the study suggest that the integration of gamification into VR training simulations may have positive effects, particularly for those new to using VR technology.

In the second study, an evaluation of the acceptance and effectiveness of virtual reality speech training (VR-ST) as a tool to improve public speaking skills was performed in the context of soft skills training. The immersive and safe environment provided by VR technology allows trainees to practice and hone their skills in an engaging and non-threatening manner. The results of this study suggest that VR-ST has significant potential as a tool for developing public speaking skills, and may be useful in reducing public speaking anxiety. This study provides evidence that VR-ST is an effective and accepted tool for developing public speaking skills. In the third study, a further investigation was conducted regarding the effects of gamified direct feedback on the technology acceptance of an evolution of the VR speech training application used in the previous study. This was investigated by comparing a direct feedback version to a simulation-based version and measuring partecipants' technology acceptance using the technology acceptance model (TAM). The results showed a preference for the direct feedback version, suggesting that direct feedback improved technology acceptance among the participants. Furthermore, it was found that VR speech training was generally better accepted by participants without public speaking anxiety, suggesting that integrating direct feedback can improve technology acceptance and may facilitate learning transfer in VR training applications.

In an additional fourth study, a novel educational concept, Adverlearning, has been developed and presented as a final contribution to the ongoing discourse on innovative approaches in learning, education, and corporate training.

The findings of this dissertation suggest that gamification is capable of positively impacting corporate XR training.

Kurzfassung

Der digitale Wandel am modernen Arbeitsplatz führt dazu, dass Menschen laufend neue Fähigkeiten erwerben und ihr Wissen vertiefen müssen, um wettbewerbsfähig zu bleiben. Für Unternehmen stellt das eine Herausforderung dar, da sie ihre Mitarbeitenden möglichst effektiv mit den neuesten Trainingsmethoden und Informationen ausstatten müssen. Dazu werden höhere Investitionen in Technologien und Weiterbildungsprogramme für ihre Mitarbeitenden benötigt. Ein Ansatz, der als mögliche Lösung angesehen wird, ist der Einsatz von Gamification in betrieblichen Trainings. Gamification kann sich positiv auf die unternehmerische Weiterbildung in diversen Anwendungsfeldern auswirken, da sie das Engagement und die Motivation der Mitarbeitenden Steigern kann. Die Verbindung immersiver Technologien, insbesondere von Extended Reality (XR), mit Gamification-Strategien bietet das Potenzial für ein immersiveres und fesselnderes Lernerlebnis für Mitarbeitende. Trotz des vorhandenen Potenzials sind die Auswirkungen von Gamification auf Extended-Reality-Corporate Trainings noch nicht vollständig erforscht.

Eine exakte und umfassende Definition für XR ist, aufgrund der kontinuierlichen und schnelllebigen Weiterentwicklung der zugrundeliegenden Technologien, schwer zu formulieren. Zudem ist das Konzept der XR vielschichtig und komplex und seine spezifische Anwendung in der betrieblichen Aus- und Weiterbildung wird somit zu einer weiteren Herausforderung.

Anhand einer umfassenden Analyse von XR konnten eine Reihe von Eigenschaften und Konzepten entwickelt werden, die dazu dienen Extended-Reality-Trainings zu klassifizieren sowie zu definieren und die Formulierung einer definitiven und langlebigen Definition ermöglichen. Um die Auswirkungen von Gamification auf Extended-Reality-Trainings in Unternehmen einschätzen zu können, wurden Untersuchungen zur Effektivität von Hard- und Soft-Skill-Trainings in der virtuellen Realität (VR) durchgeführt. Über drei separat durchgeführte Studien wurden umfassende Daten gesammelt und die Auswirkungen von Gamification auf die Effektivität von und die Akzeptanz gegenüber Virtual-Reality-Trainings analysiert. Die erste Studie umfasste eine Montageaufgabe, während sich die beiden anderen Studien auf Sprechtrainings in der virtuellen Realität konzentrierten.

In der ersten Studie wurde das Schulungspotenzial von Virtual Reality anhand einer Montageaufgabe bewertet. Der Schwerpunkt lag auf der Integration von Gamification zur Steigerung der Effektivität des Hard-Skills-Trainings. Die Teilnehmer der Studie wurden nach dem Zufallsprinzip entweder einer gamifizierten oder einer nicht gamifizierten Version des selben VR-Trainings zugewiesen. Ihre Leistung wurde anhand der benötigten Zeit und der während der Trainingseinheit begangenen Fehler verglichen. Die Ergebnisse der Studie lassen darauf schließen, dass die Integration von Gamification in VR-Trainingssimulationen positive Auswirkungen haben kann, insbesondere für diejenigen, die im Umgang mit Virtual-Reality-

Technologien noch unerfahren sind.

In der zweiten Studie wurden die Wirksamkeit von und die Akzeptanz gegenüber einem Virtual- Reality Sprachtraining (VR-ST) zur Entwicklung von Kommunikationskompetenzen für das öffentliche Reden im Kontext eines Soft-Skills-Training untersucht. Die immersive und sichere Umgebung, welche die Virtual-Reality-Technologie zur Verfügung stellt, ermöglicht es den Teilnehmern, ihre Fähigkeiten auf eine ansprechende und sichere Weise zu verbessern. Die Ergebnisse dieser Studie deuten darauf hin, dass ein VR-ST als Instrument für den Ausbau von Redefertigkeiten erhebliches Potenzial birgt und zum Abbau der Angst vor dem Sprechen in der Öffentlichkeit beitragen kann. Die Studie belegt, dass ein VR-ST ein effektives und akzeptiertes Instrument zur Entwicklung von Kommunikationsfertigkeiten für öffentliches Sprechen ist.

In der dritten Studie wurden die Auswirkungen eines gamifizierten direkten Feedbacks auf die Technologieakzeptanz der Teilnehmer gegenüber einer Weiterentwicklung der VR-ST-Anwendung aus der vorherigen Studie erforscht. Hierfür wurde eine Version der Anwendung mit direktem Feedback mit einer rein simulationsbasierten Version verglichen und die Technologieakzeptanz der Teilnehmer mit Hilfe des Technology Acceptance Models (TAM) bemessen. Die Ergebnisse demonstrierten eine Präferenz für die Version mit direktem Feedback und deuteten somit darauf hin, dass direktes Feedback die Technologieakzeptanz der Teilnehmer erhöht. Darüber hinaus konnte beobachtet werden, dass das VR Speech Training von Teilnehmern ohne Angst vor öffentlichem Sprechen besser angenommen wurde. Das deutet darauf hin, dass die Integration von direktem Feedback in VR-Trainingsanwendungen sowohl die Technologieakzeptanz verbessern als auch den Lerntransfer erleichtern kann.

In einer zusätzlichen vierten Studie wurde ein neuartiges Bildungskonzept namens Adverlearning entwickelt und als zunächst letzter Beitrag zur weiter anhaltenden Debatte über innovative Ansätze in den Bereichen Lernen, Bildung und der Weiterbildung vorgestellt.

Die Ergebnisse dieser Dissertation deuten darauf hin, dass Gamification das Extended-Reality- Training in Unternehmen positiv beeinflussen kann.

Prior Publications

The publications are ordered from newest to oldest, with the newest publication appearing first.

Niermann, P. F. J., Palmas, F. (2023, January). **Die Zukunft ist hier: Schlüsselkompetenzen mit Virtual Reality trainieren!** In: Harwardt, M., Niermann, P.FJ., Schmutte, A.M., Steuernagel, A. (eds) Lernen im Zeitalter der Digitalisierung. Springer Gabler, Wiesbaden.

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Contents

1. Introduction

It is undeniable that the world, economies, and labor markets worldwide are changing rapidly, driven by seemingly endless technological advances. The rate of progress has been exponential and will increase even more in the coming years, making it difficult for many companies to keep up with this rapid change. As a result, the conditions under which people live and work are constantly evolving [NP23; PN21].

These technological advances are likely to lead to changes and innovations that could affect people's jobs and their lifestyles. However, despite the need for digital transformation, companies are struggling to embrace it. As a result, businesses in today's society could be forced into a "survival of the fittest" scenario, in which those who do not adapt quickly enough are left behind [Pal21].

Having the right skills can be one of the deciding factors between success and failure. Therefore, understanding how to more proficiently manage difficult challenges and tasks is crucial for organizations. Consequently, now more than ever, employees must acquire the competencies and skills that will enable them to work efficiently and be fit for the economy of the future [Pal+22]. For example, acquiring digital knowledge is a skill that will be increasingly in demand over the next decade. The demand for programming and IT skills in North America and Europe is expected to increase rapidly as digital transformation becomes commonplace across all sectors [Bug+18].

The digital revolution is already having an undeniable impact on various aspects of people's lives. Communications, learning processes, and working environments have already changed significantly as a result of this development [NP23; PN21]. More changes are expected in the future, and virtually all aspects of people's lives will be affected by this transformation, with significant consequences. Innovative digital technologies promise to simplify everyday life. Technological advances also bring new opportunities, challenges, and uncertainties. One element of the future is uncertainty about which professions will disappear or emerge due to technological advances, confirming that change is an inevitable part of life. Individuals must continually develop and meet industry-specific requirements for their work. Consequently, there is a demand for continuous learning throughout life, as new skills must be learned to enable employees to benefit from changes in the workplace, stay up to date, and remain competitive in the labor market [Pal21].

Due to the changing economic environment, reskilling and upskilling are essential to meet the demands of a globalized economy. In this context, new technological possibilities can be used to support the learning process. In addition, learning must be active and forward-looking and should be understood as an ongoing process. Therefore, corporate training and learning must be reimagined as an engaging process that is based on experience and knowledge, rather than facts, and that can be supported by integrating newly available technological possibilities into learning activities to achieve entirely new forms of learning.

Incorporating immersive technology and gamification into the corporate training and learning environment has the potential to improve the effectiveness and efficiency of this environment. Immersive technologies allow learners to engage with simulated real-world scenarios and challenges, thus providing them with opportunities to develop practical skills in a controlled setting. Furthermore, the integration of gamification elements could increase the motivation of learners, provide them with feedback on their progress, and engage them in the learning process through providing sense of accomplishment. This approach could lead to improved retention of information by learners and improved learning outcomes.

1.1. Dissertation Overview

The purpose of this section is to provide a brief overview of key concepts that are central to understanding the structure of this dissertation.

First, the theoretical foundations are examined (see Chapter 2). The starting points for this work are the current challenges in business (see Section 2.1). The concept of digital transformation, which refers to the integration of digital technology into all aspects of society and the economy, is discussed. This process is accompanied by a number of challenges, including the need to adapt to new technologies, the potential disruption of traditional business models, and the need to address issues of digital literacy. Subsequently, the concept of lifelong learning is explained, which refers to the continuous process of acquiring new knowledge and skills in order to adapt to changing circumstances and maintain professional competence. In addition, the importance of public speaking for professionals and the differences between generations are discussed.

Next, a comprehensive examination of corporate training (see Section 2.2) and various learning theories (see Section 2.3) is conducted in order to gain a deeper understanding of the processes of knowledge acquisition, retention, and application. These theories have important implications for the design and delivery of educational programs, as well as for measuring learning outcomes. Another topic that will be covered is the distinction between hard and soft skills. Hard skills are specific technical abilities that are often quantifiable and easily demonstrable, while soft skills are more broadly applicable personal attributes that are necessary for success in a range of contexts. Given the rapidly evolving technological landscape and the growing importance of digital literacy, there is a growing need for individuals to engage in upskilling and reskilling in order to maintain their competitiveness in the job market. The importance of these processes and the various strategies and resources available to individuals seeking to enhance their skills and knowledge are discussed.

The presentation of theoretical foundations is concluded with a discussion of motivation theories (see Section 2.4), gamification (see Section 2.5), and video games (see Section 2.6). The use of these three methods in learning and training has proven not only to be effective in a variety of settings but also to make learning more engaging and interactive.

The subsequent chapters are organized to provide a complete overview of the studies relevant to this dissertation and to present their findings.

Chapter 3 provides an overview of extended reality (XR) technologies and their use for learning. In addition, the concept of extended reality training is defined and discussed.

The next chapter (Chapter 4) focuses on a study concerning the impact of gamification on performance in a virtual reality (VR) assembly task and highlights its potential to improve the effectiveness and efficiency of hard skills training.

Chapter 5 presents an overview of two published studies on VR-ST and its evolution toward a gamified version with direct feedback. The potential of this training approach to improve soft skills is demonstrated in this chapter.

The purpose of Chapter 6 is to provide an in-depth understanding of a novel concept called Adverlearning and to highlight its potential role in future learning, education, and corporate learning.

Chapter 7 contains a discussion of the results of this dissertation and their implications, as well as suggestions for possible directions for future research.

Finally, in the last chapter (Chapter 8), a summary of the most important points of this dissertation is presented.

1.2. Thesis Goals and Research Questions

This dissertation aims to contribute to a greater understanding of the potential impact of gamification and XR on corporate training, with a particular focus on both hard and soft skills. To answer the main research question of this dissertation, the definition of gamification was refined to better reflect the current understanding of its limitations and to provide clarity on its ever-evolving nature. Furthermore, the definitions of adverlearning, training domains, extended reality training and virtual reality training applications were developed; these applications were used in studies to assess the impact and potential of the use of gamification and extended reality technology in corporate training.

This dissertation addresses the following research question:

- *Does gamification have the potential to positively impact corporate extended reality training?*

To effectively explore the use of XR and gamification in corporate training, a long-term definition of XR training was first created for all industries to provide a clear understanding of this topic (see Section 3.4).

To assess the impact of gamification on hard skills training, a VR assembly task was designed and developed in order to compare the performance and learning outcomes between a gamified version and a non-gamified version (see Chapter 4). The purpose of this study was to explore the potential benefits of using gamification in VR training for knowledge transfer. Its central hypothesis was that integrating game elements into VR training would increase the training program's effectiveness. To test this hypothesis, subhypotheses were formulated and tested (see Section 4.2.3):

- **H1** *The experimental group* [1] *will exhibit a different distribution of error counts than the control group.*

- **H2** *The experimental group will exhibit a different distribution of error criticalness than the control group.*

The purpose of these hypotheses is to assess the potential impact of gamification on the number and criticality of errors made by users during training. In particular, this study aims to determine whether integrating game elements into the training program leads to a reduction in the total number and severity of user errors.

Two additional subhypotheses were developed to explore the potential benefits of using gamification to enhance the effectiveness of VR training for novices with no prior experience in VR:

- **H3** *VR inexperienced users of the experimental group will exhibit a different distribution of error counts than the respective part of the control group.*

- **H4** *VR inexperienced users of the experimental group will exhibit a different distribution of error criticalness than the respective part of the control group*

These hypotheses aim to investigate the impact of the gamified version of VR training on error frequency and criticalness in VR-inexperienced users. In particular, the gamified version was examined to understand whether it leads to a reduction in error counts and a reduction in error criticalness among these users.

To assess the possibilities of XR for teaching soft skills, a VR-based application called VR-ST (see Section 5.2) was developed to train people in public speaking. The purpose of the study was to systematically assess the effect of VR-ST and determine its acceptability and effectiveness as a training method by collecting data using Likert scales and open-ended questionnaires on participants' experiences and self-reported improvements. Given the limited use of VR for soft skills training and the challenges of measuring its effectiveness, the potential

[1] This group used the gamified version.

value of VR-ST as a learning tool to improve soft skills needs to be carefully evaluated. This analysis aims to contribute to a better understanding of the usefulness of VR-ST as a training modality and to make decisions regarding its implementation in corporate training programs.

To further investigate the potential of VR-ST, two new versions were developed and compared: one that incorporated gamified elements to provide gamified direct feedback, and one that offered pure simulation training without any game elements (see Section 5.3). This comparison was carried out to determine which version was perceived more positively by the learners and to assess the feasibility of each approach for future use in the context of corporate training. In addition to examining the technology acceptance model (TAM), two other constructs were examined to gain a deeper understanding of the acceptance of direct feedback and to assess the potential benefits of gamification, in terms of increasing intrinsic motivation, and the risks of sensory overload. Furthermore, this study aims to provide a more complete understanding of the factors that can affect the acceptance and effectiveness of VR-ST.

Hypothesis 1 for this study can be defined as follows:

- **H1** *Direct feedback results in higher technology acceptance than simulation-based feedback.*

Within the scope of this study, it was hypothesized that people with a fear of public speaking may be more receptive to using VR-ST, resulting in higher acceptance. Additionally, earlier exposure to VR may lead to increased use of VR-ST, which could improve the perceived ease of use. VR-ST could be perceived as more useful and thus be more likely to be used if its ease of use were improved.

Consequently, hypotheses 2 and 3 are as follows:

- **H2** *Participants with public speaking anxiety show higher acceptance of technology than participants without public speaking anxiety.*

- **H3** *Participants with prior VR experience show higher technology acceptance than participants without prior VR experience.*

Besides the aforementioned research goals, the focus was placed on developing and presenting the novel concept of Adverlearning, which aims to contribute to the ongoing discourse on innovative approaches to learning, education, and corporate training (see Chapter 6).

2. Theoretical Foundations

The purpose of this chapter is to provide a comprehensive examination of various theoretical principles relevant to the topic of corporate training. In particular, this chapter is focused on the concept of digital transformation and the challenges it poses to organizations, as well as the different learning theories that help to understand how individuals acquire and retain knowledge and skills. The distinction between hard and soft skills and the importance of upskilling and reskilling in the context of a rapidly changing technological landscape are discussed. In addition, an overview of public speaking as a valuable professional skill and an exploration of the use of gamification and video games as learning and training tools are provided.

In general, this chapter provides a theoretical foundation for understanding future-oriented corporate training.

2.1. Business Challenges

With the rise of digital technology, business faces new challenges and must adapt to remain relevant and responsive. As the business landscape changes rapidly, it is increasingly important for employers and employees to embrace lifelong learning to to current with the latest technological advances. In addition to technological challenges, a number of others challenges are based on human problems.

It is generally accepted that the ability to present confidently in front of an audience or speak in front of a group is considered a hallmark a successful person. As a result, those who lack these skills may be at a disadvantage when competing for promotions or new employment opportunities. Additionally, public speaking is frequently cited as one of the most common fears, which can manifest in a variety of ways. Despite its high prevalence as an essential skill for success in business, the value of public speaking is often under-recognized and underrated. However, public speaking can be improved through training.

Additionally, companies face generational conflicts in the workplace, which also pose challenges to individual managers. These challenges require companies to provide their employees with opportunities for continuous learning and development and to create a culturale change of openness to learning. As a result, companies remain competitive and are able to prepare their workforces for future challenges.

The following sections examine each of these challenges in more detail and provide a comprehensive understanding of each topic.

2.1.1. Digital Transformation

The convergence of digital technologies has changed culture, the way people live, and business processes. This changing environment is also affecting the way companies operate as they adapt their business models [Alm+21; Via19], while most companies are reluctant to act due to changes in the business landscape. Furthermore, many companies and individuals have not been willing to acknowledge the disruptive effects of this current development [Vey+17].

The term digital transformation is widely used and misinterpreted, leading to confusion and implying that it is imperative to ensure conceptual rigor regarding the topic [GR21]. However, the nature of the nuances of digital transformation is broad and has not been well defined. Digital transformation is gaining popularity as a buzzword and is used by various stakeholders to describe forms of innovation in their respective sectors and domains. "Digital" suggests that many changes will be influenced by information technology to provide better information to stakeholders. In addition, downstream digitization would be able to optimize, automate, and utilize a variety of production techniques. The term "transformation" describes a general process of changing a situation for the better. However, due to the evolutionary nature of this transformation, the word transformation may not be appropriate [GR17].

Gong and Ribiere [GR21] presented a comprehensive and concise definition of digital transformation, based on a thorough review of 134 related publications, as follows:

> *"A fundamental change process, enabled by the innovative use of digital technologies accompanied by the strategic leverage of key resources and capabilities, aiming to radically improve an entity* and redefine its value proposition for its stakeholders. (*An entity could be: an organization, a business network, an industry, or society.)"* [GR21]

With the advent of digital transformation, the importance of internal and external knowledge is gaining in prominence and requires corporate training [OIB18; Vey+17] and a culture of tech-savvy employees [Via19]. In addition, corporate training has evolved as a different field that requires technological progress in accordance with new technologies [KOK17].

Several companies have already invested in employee training by expanding their investments in continuous learning and growth opportunities. However, many executives are unaware of the far-reaching implications of digitization. A thorough understanding of digital transformation and the required skills, knowledge, and attitudes are essential to enable leaders and employees positions to effectively lead an organization through this process [Vey+17].

Digital transformation requires companies to invest continuously in the skills and knowledge of their employees. In this way, they can mitigate the risks associated with such a transformation. The long-term corporate training necessary to achieve this goal develops and improves the digital skills of employees, which are essential for success in today's economy [Alm+21]. Digital competence is an extremely valuable skill that is applicable to many aspects of daily life [FBR21] and seems to be associated with higher income [Don+21].

The failure of innovative projects is also often caused by the inability of decision makers in organizations to understand how best to implement technology [Pal21]. This may result in projects that do not meet the expectations of stakeholders. Furthermore, the top executives of large organizations can face severe consequences, as they can be blamed for the failure of the project and the detrimental impact on the business. This could have a negative impact on their professional reputations and future career prospects.

Taking this into account, digital literacy can be seen as an essential skill to succeed in a job [GPH20], especially for nondigital natives [Con19]. In addition, studies have shown that small- and medium-sized companies need a high level of basic digital skills. In fact, a lack of these competencies can further complicate the implementation of digitization [Lei21].

Using information and communication technologies and digital media requires a variety of skills, knowledge, and attitudes, which Ferrari defines as digital competence [Joi12]. Digital competence includes the ability to use information and communication technologies in an effective, critical, and creative manner to achieve work-related goals, gain employability, and learn. Moreover, it includes social and personal skills, which means that digital competence is also an important leadership skill; in combination with other skills, it becomes a competitive factor in dealing with complex situations in the new work environment [NS20]. Furthermore, to increase longevity and competitiveness, companies need to become learning organizations to maintain their existing knowledge and actively develop their knowledge base [PK20].

An employee's attitude towards changes and digitalization is crucial for coping with digital transformation, and this transformation is more likely to be accepted by the organization if there is openness to it [Seu+20]. Therefore, in this context, employees' individual ability and willingness to change play an essential role for companies [Ull+17]. Fundamentally, digital transformation requires technology acceptance and a positive attitude toward digitalization from employees.

To meet the diverse needs of employees in the workplace today, corporate training should leverage new technologies [NP23; Pal21]. Outdated skills are likely to result in employees becoming obsolete and consequently affecting their marketability. For this reason, companies must create an environment that encourages learning and growth at all levels. Therefore, companies that offer learning opportunities have an advantage in building long-term relationships with their employees and in attracting and retaining a qualified workforce [HK20; Wil18].

The organizational culture of a company can play a crucial role in its success in digital transformation [OIB18]. In terms of intercultural relationships and learning ability, an organization's culture is a direct reflection of the behavior of its employees. An organization's culture determines how employees behave within a company and is crucial to supporting change within the organization [GHS06; Pal21]. It should also be noted that in this symbiosis of strategy, structure, and processes, corporate culture plays an important role in the cultural sustainability and innovative ability of a company [GHS06].

2.1.2. Lifelong Learning and Learning Organization

Learning and change are essential components of private and professional life. By accepting change and understanding the gaps between a person's current situation and their intended future status quo, learning creates new opportunities for future growth [Lon11].

In recent years, there has been a growing awareness of the importance of lifelong learning [AA12; DR14]. As in the past, the notion that education was limited to our formative years is no longer valid [Fis00]. During the lifelong learning process, people can build on their previous knowledge and skills, giving them endless opportunities for improvement that could positively impact their career advancement.

Today, to be successful on the job or in other areas of life, people must have skills that go beyond what can be learned through formal education [Don+21].

The European Commission's [Eur01] definition of lifelong learning is as follows:

> *"all learning activity undertaken throughout life, with the aim of improving knowledge, skills and competences within a personal, civic, social and/or employment-related perspective."* [Eur01]

This definition focuses on activities that fall into the category of learning activities, such as formal and informal activities, and shows similarities with other definitions of lifelong learning.

Furthermore, several definitions of lifelong learning show common understandings of the meaning and characteristics of terms used (see Tab. 2.1).

Lifelong Learning (LLL)		
Autor	**Date**	**Definition**
UNESCO International Bureau of Education	1984	All learning activity undertaken throughout life, with the aim of improving knowledge, skills and/or qualifications for personal, social and/or professional reasons.
International Labour Organization	2006	All learning activities undertaken throughout life for the development of competencies and qualifications.
Technical Education and Skills Development Authority	2010	The process of acquiring knowledge or skills throughout life via education, training, work and general life experience.
European Commission Lifelong Learning Programme	2011	This refers to all general education, vocational education and training, non-formal education and informal learning undertaken throughout life, resulting in an improvement in knowledge, skills and competences within a personal, civic, social and/or employment-related perspective. It includes the provision of counselling and guidance services.
South African Qualifications Authority	2013	Learning that takes place in all contexts in life-formally, nonformally and informally. It includes learning behaviors and obtaining knowledge; understanding; attitudes; values and competences for personal growth, social and economic wellbeing, democratic citizenship, cultural identity and employability.

Table 2.1.: Lifelong learning: some definitions offered by the UNESCO-UNEVOC [UNE14]

A different view is provided by Jarvis [Jar06], who defined lifelong learning as follows:

> *"The combination of processes throughout a life time whereby the whole person—body (genetic, physical and biological) and mind (knowledge, skills, attitudes, values, emotions, beliefs and senses)—experiences social situations, the perceived content of which is then transformed cognitively, emotively or practically (or through any combination) and integrated into the individual person's biography resulting in a continually changing (or more experienced) person."* [Jar06]

By focusing on the learner, this definition recognizes the human aspect of learning, taking into account the learner's individual life experiences, body, and mind. Furthermore, according to this definition, life could be understood as a continuous learning process or learning experience.

According to all of these definitions, lifelong learning has the potential to enable individuals, organizations, and nations to become more competitive and perform better. However, there are strong expectations and perhaps even pressure to continue studying and participating in employment-related forms of learning [Tig98].

With the advent of new technologies in the digital world of work, the need for lifelong learning is becoming increasingly important for both employers and employees, underscoring the need for skilled workers and employers to increase their investment in human capital [NS20].

Companies not only must be able to learn to remain competitive and extend their lifespan; they also have the responsibility to further develop the knowledge and skills of their employees. It is possible to achieve this goal by embracing change to become a learning organization that retains knowledge within the organization and continuously improves it. Furthermore, an active and continuous effort is required to build a productive learning environment to facilitate this transformation [PK20].

In this context, a learning organization can be described as an organization that provide the necessary organizational structure and capacity to develop an enabling environment that ultimately leads to knowledge development and financial viability [WK18].

2.1.3. Public Speaking

It is general knowledge that successful communication is a key asset that can be applied to a wide range of professional situations, including politics, education, and the workplace. In organizations, individuals with strong communication skills are crucial because their communication skills allow them to have a significant impact on the company and be successful in management [Pal+19a].

Furthermore, the ability to effectively communicate in public has many benefits, including the ability to positively influence others, develop leadership capabilities, and increase authority [1] [Har17].

Ineffective human resource management contributes significantly to the costly and inadequate flow of communication. Additionally, business losses from poor communication can

[1] Thought leadership.

result from a lack of preparation, inefficient speakers, an overwhelming amount of information presented, and other communication difficulties. Understanding the sources of ineffective communications and taking steps to avoid them are essential for organizations to mitigate these costs [Pal+19a].

Public speaking is the act of preparing and presenting a speech in front of an audience. To achieve this goal, it is essential to understand the audience and the goals of the speech, to choose elements that motivate the audience to pay attention, and to deliver an effective message. Those who are successful in public speaking understand that speech preparation is the key to success. Moreover, to avoid mistakes, their material should be planned, organized, and revised in advance [Har17; Hau22; SE16].

According to Harris [Har17], public speeches can be classified into three types:

- **Informative:** One of the most popular types of public speaking is informative speech. Informative speeches serve to exchange information or impart knowledge about a specific topic. The audience is informed about new topics or enlightened about things that they were not aware of. Speeches of this kind are common in the workplace.
- **Persuasive:** This type of speech aims to persuade a group of people. For some individuals, making persuasive speeches is essential to achieving and maintaining professional success.
- **Ceremonial/Entertaining:** Since early ancient Greece, ceremonial and entertaining speaking has played a prominent role in society. It is common for such speeches, from short introductions to longer speeches, to be given on many occasions, such as wedding toasts or eulogies. In addition, ceremonial speeches may include after-dinner speeches and motivational speeches.

Despite its diffusion and importance, public speaking can be challenging for many people due to lack of experience and other factors [Pal+19a; PK21]. However, by understanding how effective public speaking is built (see Fig. 2.1) and practicing it, it is possible to improve public speaking skills.

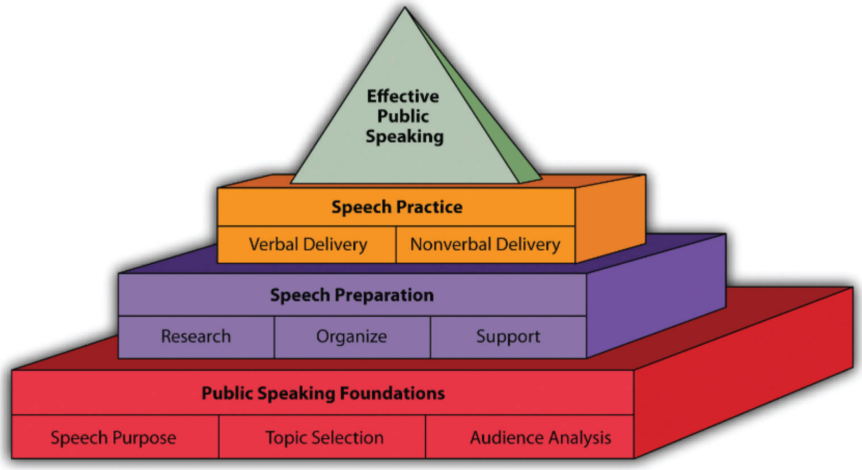


Figure 2.1.: Effective public speaking. Retrieved from Harris [Har17]

Palmas et al. [Pal+19a; Pal+21] summarized the main criteria for a well-received and successful public speech as follows:

- **Body Language:** In order to deliver a successful speech, it is necessary to build a relationship between the communicator and the audience. Whether the communication is verbal or non-verbal, the body plays a major role. The body language of a speaker during a speech reflects both confidence and well-being. This also affects how the audience perceives the speaker. Therefore, it is important to be aware of the different ways body language can be used to make a positive impression. An important aspect of body language is posture. Confidence can be instilled by assuming an open posture with one's feet planted firmly on the ground. In addition, a person with uncrossed hands and arms appears approachable and open. Another way to communicate effectively is through gestures (see Fig. 2.2). The most effective place to use persuasive gestures is in an imaginary TV window between the head and the waist. When a speaker uses gestures within this frame, the likelihood that the audience will see and understand their gestures increases.

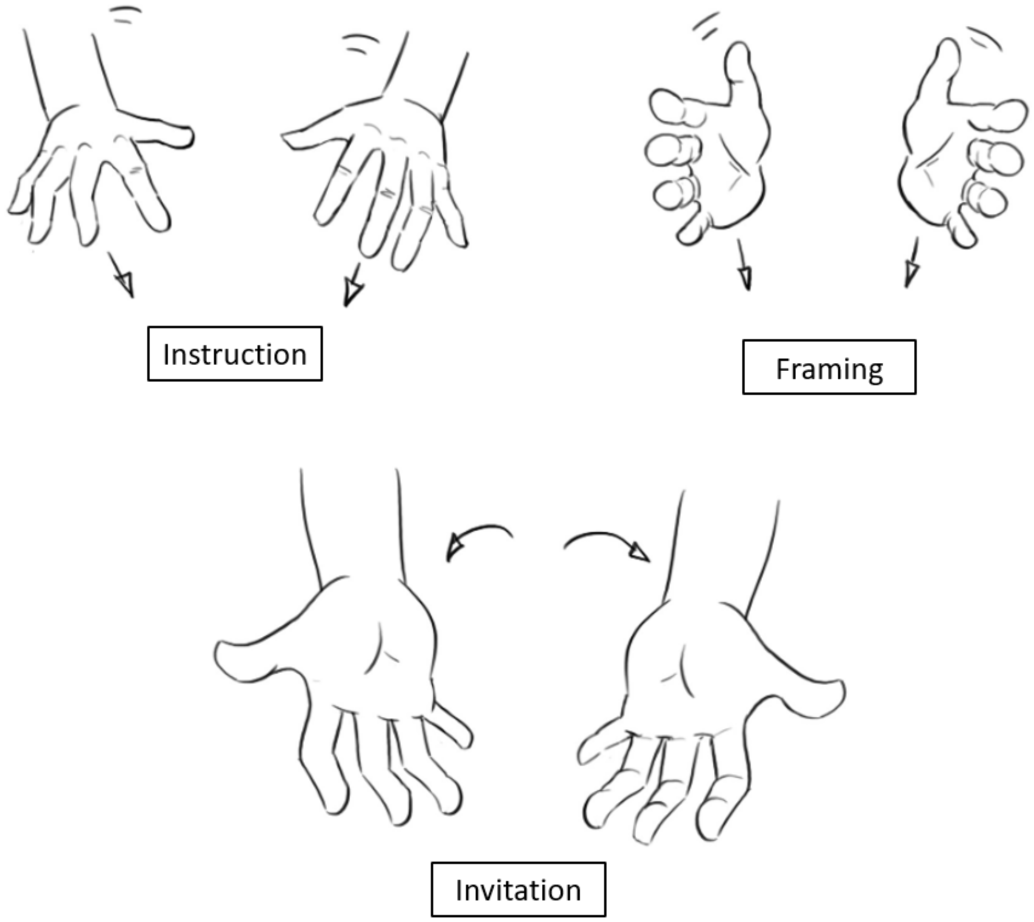


Figure 2.2.: Hands orientation. Own representation based on Schott [Sch21]

- **Eye Contact:** Eye contact is an essential part of a speech that creates a sense of connection and engagement with the audience (see Fig. 2.3). In addition, it is important to maintain the audience's attention and present content effectively. The key to maintaining eye contact with an audience of just a few people when giving a speech is to take turns looking at each listener in the room. Considering that employees communicate primarily in meetings, this approach is beneficial in everyday business situations. When communicating with a larger audience, it is a good idea to alternate making eye contact with the audience in different parts of the room so that each listener feels included and therefore more apt to pay attention.

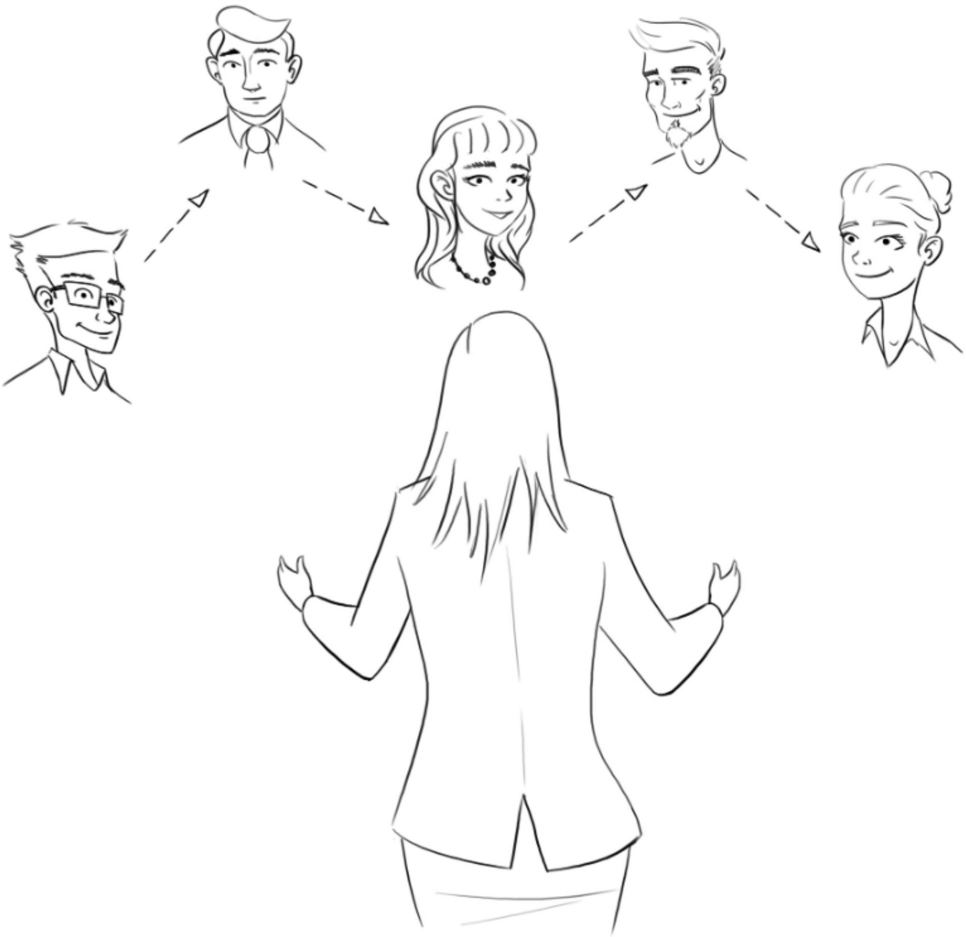


Figure 2.3.: The connection with the audience is established and maintained through eye contact. Own representation based on Schott [Sch21]

- **Language:** Speakers need to maintain proper posture and breathe calmly in order to ensure a distinct volume and the smooth flow of their speech. The aim of this technique is to make the speech more pleasant to listen to by giving it a melody that is pleasant to the audience. For maximum audience understanding, the speaking rate should vary between 100 and 150 words per minute. In addition, eliminating filler words can improve the effectiveness of communication, improve the listener's perception of the speaker's competence, and direct audience's attention.

There is significant fear and anxiety [2] related to public speaking among employees in professional settings. In addition, people consider public communication to be one of the most threatening and challenging situations [Gal+22; Pal+19a]. Because employees are expected to

[2]This condition is also known as public speaking anxiety.

communicate their ideas and concepts to colleagues in the professional environment, public speaking situations are often unavoidable. According to research, these situations can lead to high emotional distress for some employees. In addition, this emotional burden of public speaking can lead to a range of mistakes during presentation, such as poor body posture, avoiding eye contact, speaking with one's back towards the audience, and speaking too quickly without catching one's breath [PK21]. Anxiety associated with public speaking can cause distress in some individuals.

Anxiety related to public speaking has been recognized as a social phobia and an anxiety disorder [3]. A primary symptom of this type of anxiety disorder is a strong fear of (social) situations that evoke complex emotional reactions [Pal+21].

Fear is conceptualized in terms of the connection of two or more associative networks [4] that are responsible for maintaining information about the fear-eliciting stimulus, the responses to the stimulus, and its meaning. The fear structure is activated by associative networks as soon as the feared stimulus appears in the environment. As a result, the fear structure is reinforced by avoidance behavior that inhibits learning [KF15].

One therapy method that has been shown to reduce symptoms of public speaking anxiety is gradual behavioral exposure. Through behavioral exposure, participants are exposed to repeated challenging public speaking situations in a safe environment [Eng+12; Pal+21]. Additionally, another goal is to reduce the emotional response associated with public speaking by practicing presentation techniques. In repeated exercises, the participants will become familiar with the skills required to give a presentation successfully [5] [Pal+21].

Notably, public speaking skills and behaviors can be taught and learned to enable speakers to develop their confidence in real-life situations [Har17; Pal+21]. In addition, new, technologically enhanced training methods offer innovative training methods. An example is the use of VR as an innovative approach for exposure to challenging situations over time. Upon adoption of VR, a safe training environment can be created in which real-life situations can be simulated and faced according to the individual requirements of the participants [Pal+21; Pal+22; Pre+22].

2.1.4. Engagement and Generational Clash

Employee motivation is a crucial factor in the long-term success of any company. According to Gallup [6], employee engagement can be defined as the extent to which employees are interested and enthusiastic about their work and workplace. Employee engagement can also be described as the extent to which organizations can measure and manage employee perceptions of key elements of workplace culture [Gal20].

A long-term study [7] showed a steady tendency without significant fluctuation that around

[3] DSM-IV: diagnostic and statistical manual of mental disorders.
[4] Cognitive fear structures.
[5] E.g. Participants can improve their body language, eye contact, and communication skills.
[6] A global analytics and advice firm.
[7] The study is called "Gallup Engagement Index". Data were collected in Germany, and this study lasted from 2001 to 2019.

15% of employees [8] of a company felt a strong emotional bond with their employer [Nin19]. Given that most of the employees reported little or no engagement, companies should consider improvements to be necessary. In addition, in more than five decades of research on employees engagement, Gallup has found that engaged employees in all industries, at all company sizes, in all countries lead to better business outcomes than their peers, and even in tough economic times [Gal20].

One of the biggest challenges companies face is understanding the importance of employee engagement and how to engage them. Furthermore, this challenge carries a high level of risk, considering that the cost of lost productivity caused by disengaged employees is estimated to be 7.8$ trillion worldwide [9] [Pen22]. It has been found that employees are more likely to perform well when rewards are not limited to money or other material factors [10] [NS17b]. However, the personal needs and goals of employees can come into conflict with organizational requirements and company goals [11].

Culture and generational diversity have increased in the workplace, resulting in differing values and needs among employees [Cuc+21]. Consequently, there are generational differences and distinguishing characteristics [Ber14; Cla17; Nie16] (see Fig. 2.4).

Generation	X	Y	Z
Birth period	1965-1980	1980 - 1999	2000+
Major global events	➢ End of Cold War ➢ Vietnam War ➢ Fall of the Berlin Wall	➢ Technology ➢ 9/11 terrorist attacks ➢ Social media ➢ Google	➢ Global crisis ➢ Mobile devices ➢ Arab spring ➢ Data cloud
Device most frequently used	➢ TV set ➢ Desktop computer	➢ Smartphone ➢ Laptop	➢ Tablet ➢ Smartphone
Most frequent communication methods	➢ SMS ➢ Phone ➢ e-mail	➢ SMS ➢ Social media ➢ Online media	➢ Social media ➢ Online media
Technologies	➢ Tool that I use	➢ Perfect tool that I use	➢ Real world and virtual reality are interwoven
Feeling of security	➢ Permanent job ➢ Skills	➢ Skills ➢ Money	➢ Relationships
Work outlook	➢ Career ➢ Job	➢ Work-life balance	➢ Working at home ➢ Multitasking
Major characteristics	➢ Flexibility ➢ Individualism ➢ Scepticism towards authority ➢ Job security	➢ Technological convenience ➢ Global communications ➢ Optimism ➢ Freedom ➢ Flexibility	➢ Distrust of political systems ➢ Permanent connection with the Web ➢ Freedom ➢ Mobile generation

Figure 2.4.: Overview of the generations. Adapted from Nieradka [Nie16]

8 The survey was conducted among 1,000 employees. The results reflect the demographics of the German workforce aged 18 and over.

9 This corresponds to 11% of global gross domestic product.

10 There is a widespread belief in the business world that material factors are the most effective way of motivating employees.

11 In contrast to corporate goals, employees generally place more value on opportunities for personal and professional development and advancement, according to Palmas [Pal21].

Although employees have different values, interests, and needs and belong to different generations, the workforce must work in harmony and function as a cohesive organizational entity. Furthermore, human resource management must take into account these generational differences and characteristics in order to find ways to motivate employees by satisfying their individual or generational interests [Pal21].

Conversely, the increasing attention paid to generations has been accompanied by a rising number of studies questioning the validity of empirical evidence of generational differences, due to oversimplified generational clustering [12] [PU21]. Based on the current state of research in this area, it is evident that further research is needed to determine the extent to which such differences exist and how they can be efficiently managed in the workplace.

For organizations affected by generational conflicts, a targeted investigation may be required and an intervention such as team building or diversity training may be recommended [Cuc+21], given that there are often generational differences in education and training environments [Cla17].

2.2. Corporate Training

Training on the job has historically been a crucial component of acquiring skills and knowledge. Furthermore, training has a proven history of developing and improving professional competencies [Bel+17; Car03; MMK20].

The industrial revolution led to significant changes in the way companies operate. To remain competitive in the marketplace, companies had to not only adopt new technologies but also adapt to them. This adjustment process was further complicated by the emergence of a skills gap resulting from the limited availability of professionals to fill positions within the company. As a result, many organizations introduced internal training programs to fill this skills gap. As technology advances, the need for a skilled workforce becomes more important [Car03].

In recent years, the importance of human capital for business success has become increasingly recognized [Qui14]. In the literature on human resource management and human resource development, training, development, and education have been the subject of considerable debate and discussion [Gar97]. While training and development share similarities, they also possess characteristics that distinguish them. In addition, training and development, as some of the critical functions of human resources, are management-initiated activities carried out within an organization [DS20].

In this context, training aims to provide employees with the skills needed to perform their duties effectively [Car03; Rui+20], while development focuses on long-term professional advancement and prepares employees for future organizational roles [Car03; DS20]. Consequently, both training and development programs serve as fundamental and indispensable elements to facilitate employees' acquisition of knowledge and competencies that are essential for performing effectively in their respective positions.

[12] For example, the different generations are classified strictly by year but different characteristics can be observed within a generation.

A more effective strategy for organizations would be to adopt an integrated approach to training, development, and education that recognizes the interconnectedness of these activities and the importance of learning as a unifying principle [Gar97] [13].

There is a widespread misconception that training is an expensive investment without guarantee of return [LP00]. Keeping training costs low is one of the biggest challenges for many companies. The adoption of technology provides a viable solution to this problem, as it allows low-cost training that can be performed almost anywhere, anytime [Bis19]. Training programs often fail to meet the needs of employees when they are not properly linked to the organization's objectives [LP00]. For training to be considered valuable, it should result in positive changes in behavior in the real workplace [Bri06]. Rather than viewing training as a cost, it should be viewed as an investment that can lead to a more productive and engaged workforce. This can lead to productivity gains. Therefore, training can significantly affect employee performance and behavior if it is designed and implemented properly [LP00].

In order to determine a training's success or failure and to improve the quality of future programs, evaluation is essential. Furthermore, evaluating the effectiveness of corporate training is important to ensure that it meets the needs of the company [Gue15]. The evaluation process helps to assess the different aspects of the training, including its content, its design, the success of the learners, and the benefits provided to the organization. Training evaluations are also imperative in improving the quality of future training programs [Rui+20].

It is also important to find common ground between concepts and terms on which to make these evaluations. A review of the literature on training evaluations indicates that the numerous aspects of training program evaluation have been described using several terms. Different terms are sometimes used to refer to the same activities, and sometimes, multiple authors cover a variety of evaluation activities using similar or the same terms. This inconsistency in terminology makes it imperative for those involved in the evaluation of training programs to first establish a common language before evaluating the training programs [LP00].

In this dissertation, corporate training refers to an intentional and organized process intended to enhance the expertise and skills of an organization's workforce through the use of evidence-based methodologies and technology. Corporate training aims to equip employees with the skills and knowledge relevant to their current or future professional role. By increasing the performance and competence of employees in the workplace, corporate training strives to increase the overall productivity and competitiveness of an organization in both the short and long term.

2.2.1. The Importance of Employee Skills

The importance of investing in training and development is underpinned by a wealth of research on the subject. In recent years, technological advances have made it even more important for companies to invest in their people [ASB15]. In fact, there are several positions

[13] Such an approach would allow companies to optimize the development and use of human capital and improve the overall performance of the organization.

within an organization that require specific skills that cannot be learned through formal education [Eur19].

According to Ursula von der Leyen [14] [Eur22], skills are an important aspect of economic growth:

> *"The green and digital transitions are opening up new opportunities for people and the EU economy. Having the relevant skills empowers people to successfully navigate labour market changes and to fully engage in society and democracy. This will ensure that nobody is left behind and the economic recovery as well as the green and digital transitions are socially fair and just. A workforce with the skills that are in demand also contributes to sustainable growth, leads to more innovation and improves companies' competitiveness."* [Eur22]

In this context, skills can be seen as competencies or qualifications that employers and employees must have for a company to operate effectively and, in turn, for the economy to function effectively. Although some of these skills may be known, others may not and must be identified to ensure proper training and development. Several factors contribute to changes in the skills needs of the economy. In an organizational setting, the typical approach to addressing a skills gap is to find individuals with the necessary competencies to meet evolving business needs. However, this may not always be a viable or feasible solution. A lack of employees with the required skills may be due to quantitative constraints that lead to the existence of a skills gap. In other cases, this gap may be due to the introduction of new technologies [FBR21]. However, companies must work to bridge the gap to be successful.

A recent study by the European Investment Bank [JCT18] confirmed the importance of skill development. It found that achieving future prosperity requires a focus on developing skills to create growth and inclusion in economies, while laying the foundation for future innovation. Investing in education and training helps countries unlock the potential of their workforce and enables them to participate in the global economy. Furthermore, skills are not only important for economic growth but can also lead to positive changes in societies that are crucial for social development [JCT18].

According to Nicholas Schmit [15] [Eur22], investing immediately and heavily in people's skills is imperative:

> *"Skills mean jobs – quality jobs. During the European Year of Skills, we have an opportunity to connect the dots between labour market-oriented training and labour shortages. To make sure that the transition to a carbon-neutral economy is truly fair and inclusive, we need massive and immediate investment in people's skills."* [Eur22]

In most organizations, learning and development are an integral part of improving the competitiveness and life of employees. These ultimately contribute to their success [Arn17].

[14] President of the European Commission.
[15] European commissioner for jobs and social rights.

Furthermore, to empower their employees, organizations should invest in and provide a variety of learning resources and tools to allow employees to improve their skills [Arn17; CMP20].

In recognition of the fact that the effectiveness of training transfer on the job can sometimes be low, organizations should carefully consider all the factors involved when designing training interventions to optimize outcomes [Sak02; SB06]. In addition, increasing labor competition, as accentuated by technological advances, has made it more necessary for people to invest in themselves [Arn17; Tho03].

Organizations must examine the prerequisites for success to determine their individual and organizational learning needs. To support the optimal development of an ideal employee, it is necessary first to establish what skills current employees are lacking. By comparing current skills with the skillset of ideal employees, companies can determine how to adapt training programs to improve the performance of the workforce [Arn17].

2.2.2. Hard Skills and Soft Skills

When defining skills, it is helpful to recognize that they are broad terms that can have a variety of meanings. Skills can include experience and knowledge acquired over time or specific abilities that can be used in a professional environment to complete tasks or solve work-related challenges. A person's skills are usually classified according to their level of qualification, such as low-skilled, medium-skilled, or high-skilled [FBR21].

Developing effective corporate training requires an understanding of skills that traditionally fall into two categories: hard skills and soft skills. It is generally accepted that hard skills are more transferable to the workforce than soft skills. Furthermore, the perception that soft skill training is ineffective has led to the misconception that companies should hire employees who already have soft skills, rather than assuming that they can develop them through training [LP11].

According to Laker and Powell [LP11], hard (see Tab. 2.2) and soft skills (see Tab. 2.3) training can be distinguished based on the effects of the following characteristics on trainees:

- Prior learning and experience
- Trainee resistance to learning
- Organizational resistance to transfer
- Managerial support and resistance
- Identification of training needs and objectives
- The immediacy and salience of feedback and consequences
- Degree of similarity between training, work, and work environments
- Level of proficiency (mastery) achieved in and after training

- Degree of self-efficacy achieved
- Scope of training responsibilities and methods of instruction

Hard skills are those that can be quantified using certain metrics (e.g., they are commonly measured in formal education and technical training) [Dal+15; Rob12]. For hard skills, it is likely that the transfer environment and the need for other skills will change. The cause of this phenomenon is the simultaneous development of technology and the skills required to keep up with it [LP11]. In contrast, soft skills are more abstract and are defined as a set of skills that extend beyond technical expertise.

Characteristic	Hard-Skill Training
Prior learning and experience	Less prior experience
	Less negative transfer
Trainee resistance to learning	Less trainee resistance
Organizational resistance to training	Less organizational resistance
Managerial support and resistance	Greater support and less resistance
Identification of training needs and objectives	More precise identification
Immediacy and salience of feedback and consequences	More immediate and more salient on the job
Similarity between training, work, and work environment	More immediate and more salient on the job
Level of proficiency (mastery) achieved in training	Greater degree of proficiency (mastery) achieved
Degree of self-efficacy achieved	Greater degree of self-efficacy achieved
Scope of training responsibilities and methods of instruction	Hard-skill trainers and methods of instruction are frequently hard-skill specific

Table 2.2.: Characteristics of hard skills training. Adapted from Laker and Powell [LP11]

Soft skills can be defined as a comprehensive term that refers to a diverse and broad categorization of interpersonal or intrapersonal skills, including but not limited to effective communication, professional behavior, emotional intelligence, leadership, teamwork, negotiation prowess, and the skills related to managing time and stress [DS13; LP11; FBR21]. Essentially, soft skills encompass personality traits, behaviors, and the natural qualities of individuals, and they promote a positive work environment [Dal+15; LP11]. Consequently, soft skills are harder to develop [LP11; PE16] and have gained increasing attention in recent years [LP11; MWI97; Wel05] due to their relevance when introducing new technologies [Seu+20].

Characteristic	Soft-Skill Training
Prior learning and experience	Greater prior experience
	Greater negative transfer
Trainee resistance to learning	Greater trainee resistance
Organizational resistance to training	Greater organizational resistance
Managerial support and resistance	Less support and greater resistance
Identification of training needs and objectives	Less precise identification
Immediacy and salience of feedback and consequences	Less immediate and less salient on the job
Similarity between training, work, and work environment	Less immediate and less salient on the job
Level of proficiency (mastery) achieved in training	Lesser degree of proficiency (mastery) achieved
Degree of self-efficacy achieved	Lesser degree of self-efficacy achieved
Scope of training responsibilities and methods of instruction	Soft-skill trainers and methods of instruction are frequently soft-skill specific

Table 2.3.: Characteristics of soft skills training. Adapted from Laker and Powell [LP11]

An individual's past experiences influence how they respond to new circumstances. In addition, learning new skills is particularly challenging, as previous experiences often provide the framework for understanding new concepts. This means that most of the course participants are familiar with the material presented in soft skills training. Prior knowledge can also be a deterrent, as participants may be resistant to learning new skills. In this context, it is essential that trainers know the previous experiences and skills of the participants [LP11].

According to Tyson [Tys20], the acquisition of soft skills together with cognitive and/or academic skills, leads to better economic, employment, and academic outcomes. As a result, these traits are believed to translate into greater success at work [Tys20]. In addition, executives consider soft skills to be among the most important employability skills among job applicants due to their direct impact on the workplace [Rob12]. Therefore, it is imperative to equip students with the soft skills required to succeed in their careers as new professionals [SN16].

2.2.3. Skill Gap

It is generally accepted that there will be a surplus of low-skilled workers in the coming years. Previous studies have also predicted a shortage of skilled workers for the global workforce due to an estimated surplus of low-skilled workers [Jan+15; Mt+16; MMK20]. As a result, many vacant positions will remain unfilled and workers will be unemployed or underemployed [Bis19], creating a significant challenge for companies when it comes to finding suitable candidates.

When the skill set required for a job does not match the skill set possessed by the employee, a skill gap occurs. This gap is considered a problem in our contemporary economy [FBR21] that can hinder employers and employees from meeting the needs of the industry, resulting in lower productivity and higher employee turnover rates [Bis19; Cap15].

In order to address the skills gap, it is essential to provide adequate knowledge and training to allow employees to interact effectively with other people and develop the personal attributes of each individual [Gya+14].

2.2.4. Upskilling and Reskilling

The learning and development industry often relies on counterproductive practices. Over the past quarter century, organizations have changed drastically, but their approach to learning solutions based on unified or event-based approaches has not. In contrast to maintaining a stationary organizational learning process, it is imperative to embrace a continuous and widespread learning program [Qui14].

In today's fast-paced and volatile work environment, there is a new urgency for organizations to upskill and reskill their workforce [Pal21; PN21]. In fact, many of today's organizations rely on their people to develop skills in order to perform at their best, although every organization has employees with different skill levels and competencies. Overall, this workplace reality suggests that companies must focus on training their employees and confirm that lifelong learning has become an inevitable necessity for success in today's workplace and for surviving in an ever-changing world [Con19].

Upskilling can be viewed as a process that helps employees quickly adapt to changing work environments, technologies, companies, and industry developments. This can be achieved by updating, refreshing, and reviewing the employee skillset through continuous learning and training programs [Con19]. This allows employees to improve their current skills or deepen their skills to make a meaningful impact in their area of expertise [Pal21]. Furthermore, the skill gap can be filled by upskilling, which can contribute to increased revenues, productivity, and efficiency, as well as cost savings and improved customer satisfaction [Gya+14].

Reskilling has become an increasingly important part of preparing employees for changes in business, as it consists of training current employees in entirely new job-specific knowledge and skills to be prepared for future challenges that may also arise from technological advances [Li22; Pal21].

Nowadays, not all types of employee development can be placed in a single category, and training and development can combine elements that best suit their needs, allowing for a customized approach that better suits the specific needs of organizations. The Confederation of British Industry, which represents around 190,000 companies and includes more than 70 universities and 30 colleges, has examined the concept of training and learning new techniques in the business sector. Their results emphasize that employee training, learning, and personal development are changing based on the latest advances in technology and the labor market [Con19]. This changing labor market means that companies must focus on empowering their workforce through training and personal development to remain competitive.

As the future of work becomes more uncertain, it is imperative that the upskilling and reskilling processes allow people to acquire the skills they need to respond to challenges such as the 2020 COVID-19 pandemic and others they may encounter in the future. The unpredictable global impact of the COVID-19 pandemic required companies to have a high degree of versatility and a culture of innovation regarding employee training programs [NP23]. The lockdown measures [16] have led almost all companies to offer digital and virtual training

[16] Stay-at-home restrictions.

formats [Int21; NP23; PN21]. The response has been to increase the amount of online learning available to companies and organizations. However, some challenges have been encountered due to the limited digital literacy of employees and the lack of infrastructure to provide online training [Int21]. Besides the traditional training methods employed by companies, innovative methods, such as VR and augmented reality (AR), could offer advantages in such scenarios to support upskilling and reskilling processes. However, the willingness and courage to change of decision makers in companies, as well as the desire to adopt innovative learning concepts, are fundamental with respect to new technologies, such as XR [PN21].

2.2.5. Skills for the Future

> *"The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn."* [Oxf16]

These forward-looking observations on education by Alvin Toffler [Joh22] suggest that teaching students how to learn, unlearn, and relearn can bring an influential new dimension to education [Oxf16]. However, with technological innovations rapidly developing and changing, it becomes challenging to identify and forecast what future skills and knowledge will be required to remain competitive in the economy of tomorrow [FBR21]. Additionally, to actively prevent skill gaps, it is necessary to identify skill shortages through sectoral forecasting [Eur17] and plan accordingly. Thus, corporate training should become a more integral part of an organization's strategy [Car03].

Furthermore, individual skills can develop over time, and this process is influenced by several factors, such as the individual's age, level of education, environment, and peers [Kau+14]. This suggests that organizations can potentially benefit from adopting new learning methodologies and technologies to support their corporate training.

A report released by the World Economic Forum in 2016 identified the ten skills that employees must have or develop by 2020 and emphasized the importance of soft skills [Wor16]. Recently, the World Economic Forum predicted that the skills necessary to perform many jobs will change significantly. In addition, employees will face an increasing instability of skills, underscoring the importance of reskilling and upskilling as essential to remain competitive [LRZ18; Wor20b]. Furthermore, the World Economic Forum also predicted that in the future, a significant number of jobs will require some form of digital skills. This implies that a training ecosystem needs to develop within an organization to effectively support the development of employee skills [LRZ18; Wor20a] and that a training ecosystem within an organization must evolve to effectively support the development of employee skills.

Given what has been discussed previously, digital transformation can be viewed as an inevitable and irreversible process that challenges companies to train their employees for unpredictable, emerging professions, and unpredictable specific skills needed for their success.

A 2021 study conducted by the McKinsey Global Institute [Don+21] looked at the types of skills that will be needed in the future and found that manual, physical, and basic cognitive activities will decrease, while higher cognitive skills that require technological or social skills will increase and gain importance [Don+21]. Furthermore, these findings are supported by other studies [FBR21; LRZ18]. The study identified 56 elements of talent in 13 skill groups and four broad categories (cognitive, digital, interpersonal, and self-leadership) that will benefit all citizens and will enable them to thrive in the future work environment (see Fig. 2.5). Furthermore, these findings indicated that people with college degrees performed better in the 56 different areas of talent and are better prepared for changes on the job [Don+21].

Figure 2.5.: The 56 foundational skills. Retrieved from Dondi et al. [Don+21]

The study found that the respondents were least proficient in two skill groups in the digital category: software usage and development and understanding of digital systems. They also underperformed in cognitive skills such as communication, planning, and working methods [Don+21].

With the increasing number of professions being redefined by digital technologies, it is also imperative to adapt education to the needs of the future. The current education system does not seem to prepare students, who are future workers, in the best possible way for the challenges of the digital revolution because it is based heavily on the curricula of previous industrial revolutions [NS20].

In summary, while the exact skills that employees will need in the future are uncertain, organizations must prepare in advance. Furthermore, the results of the McKinsey Global Institute [Don+21] suggest which topics should be prioritized in corporate training programs.

2.3. Learning

In the broader context of a competitive society, learning is widely recognized as a critical element for individual and organizational success. Given the multifaceted and complex nature of learning, applying learning theory principles could be a valuable tool to improve the effective use of resources within an organization.

Learning theories are a fundamental aspect of understanding the mechanisms and processes of learning. Various theories offer different perspectives on how learning occurs, and it is important to note that these theories are not inherently geared toward the application or optimization of resources for sustainable and economically efficient learning. Rather, they serve to provide a general understanding of the underlying principles and mechanisms of learning. The value of learning theories lies in their potential to help develop a broader and more accurate understanding of learning and to support the identification and implementation of more effective instructional practices. In this sense, learning theories, while not having direct practical relevance, play a crucial role in supporting the advancement of our understanding of learning and ultimately in facilitating improvements in the learning process.

The forthcoming topics will include a comprehensive examination of learning theory, types of learning, and educational technology.

2.3.1. Learning Theory

Learning is a complex and multifaceted phenomenon that has significant implications for individuals and society. Although no universal definition of learning is widely accepted, there is general agreement that learning is a process by which people acquire and apply knowledge, skills, and values. Learning can take place in both formal structured settings, such as schools and universities, and in informal settings, such as at home, at work, and through daily life experiences. The impact of learning is also far-reaching, affecting not only individuals but also families, communities, organizations, and societies [Sch12]. As new technologies advance, it becomes increasingly difficult to provide effective new learning opportunities. Moreover, the application of appropriate approaches based on learning theories may vary depending on the nature of the subject matter, the cognitive profile of the learners, and situational factors [PLT10].

Although the exact nature of learning is unclear, the criteria considered central to learning are generally accepted (see Tab. 2.4). Furthermore, there is a wide spectrum of interpretations and beliefs between individuals regarding core concepts and mechanisms of learning [Sch12]. These beliefs originate from a variety of sources, including introspection, personal experiences, external observations, and academic studies [Wan12].

Learning involves change
Learning endures over time
Learning occurs through experience

Table 2.4.: Central, generally accepted learning criteria. Own representation based on Schunk [Sch12]

The creation of learning environments is based on three main learning theories: behaviorism, cognitivism, and constructivism. However, these theories predate the significant impact of technology on the learning process. Today, theories that convey principles and learning processes must reflect the social contexts in which learning now takes place.

Educational approaches often involve different learning theories, which can be categorized as follows [NP23]:

- **Behaviorism** focuses solely on the connection between stimulus and response. Accordingly, human behavior, including learning, is determined by consequences. When a stimulus (input) is received, a response (output) is produced. The human brain is viewed as a black box, and the fact that reality is a construct of the brain is not taken into account. In addition, neither the motivation nor the emotion of the learners is considered in this theory. Only the result counts, not how new behavior arises [McL03; NN09; NP23]. It is asserted by Ansar et al. [ARR21], that the behaviorist perspective is and will remain the most effective strategy to achieve successful results through educational processes.
- **Cognitivism** assumes that learners play an active role in the observation and experience process, through which they can access their stored knowledge. Learners establish a solution-oriented and goal-oriented action plan [Arp13; NN09]. The teacher largely determines what is learned and how and intervenes actively and supportively if necessary. Likewise, learners are responsible for developing their own learning or problem-solving strategy by choosing appropriate methods and reflecting on the outcomes and the learning process [McL03]. In summary, procedural knowledge instead of pure factual knowledge is in the foreground.
- **Constructivism** is an epistemology based on psychological and philosophical principles rather than a theory in itself. This viewpoint does not postulate that learning principles can be determined and experimentally validated; instead, it claims that learners generate their reality and learn through perceptual observations. Cognition and perception are constructive and nonrepresentative activities of the observer. As a result, reality can be seen as the self-description of the brain based on past experiences in which observer

and matter merge to form a cognitive world, our reality. The constructivist perspective emphasizes the mutual relationship between individuals and their surroundings in the enhancement and acquisition of skills and knowledge [NN09; Sch12]. According to this learning theory, along with the processing of information, new things, concepts, or truths are created. Furthermore, learners and teachers are two distinct, loosely coupled systems in which learners develop their own knowledge and do not rely on teacher-mediated instructions [McL03].

- **Connectivism** is a theory of learning for the digital age, the central idea of which is that learning occurs in self-organized systems and networks, in which interpersonal relationships are formed as part of an interconnected network [Sie05]. This concept clearly refers to the relationship between human learning and the widespread access to knowledge enabled by the current technological environment [CS20]. Although connectivism provides a useful lens through which teaching and learning can be better understood and managed, technologically enabled networks are unlikely to be explained by a single theory.

As reflected in the following learning theory, Nagowah and Nagowah [NN09] assessed the strengths and weaknesses of their approach:

- **Behaviorism**
  Strength: Throughout the learning process, the learners are aware of and respond to a defined goal to ensure that they behave similarly under the given circumstances. ***Example:*** A monthly sales report should be produced by the same query each month.
  Weakness: Learners often find themselves in situations where they need to react in real time, but the instructions presented are incongruent and do not match their previously learned information.

- **Connectivism**
  Strength: Learners are trained to approach a task in the same way repeatedly. ***Example:*** Customer service departments need to be able to answer the same questions in the same way.

  Weakness: The individual learns a method to perform a particular task, which may not always be the most appropriate method in the circumstances. ***Example:*** In programming, there can be different ways to write a certain code to perform a same task and produce the same results, but some may be less efficient than others.

- **Constructivism**
  Strength: Due to the ability to relate new life challenges to similar problems solved in the past, learners will be better prepared to deal with real-world situations. ***Example:*** Students can apply the knowledge gained from solving previous case studies to solve a new one.
  Weakness:In situations that require conformity in thinking and behavior, this learning

theory is not applicable. ***Example:*** Key performance indicators cannot be evaluated based on individual understandings of them.

Learning theories have evolved from behavioral to cognitive, situational, and sociocultural explanations, shifting the focus from behavioral change to knowledge acquisition to social participation [Shu01]. Despite the differing interpretations of learning theories among scholars, they are useful as guidelines to help individuals in specific situations. In addition, any theory of learning is designed to lead learners to a change in perspective through growth and development [Wan12].

Given the importance of learning, developing effective learning applications requires examining its complexity and trying to understand its many aspects. According to contemporary theories, a meaningful learning process has the following characteristics [Shu01]:

- active
- self-regulated
- constructive
- cumulative
- goal-oriented
- context-dependent
- social
- cultural
- interpersonal

Understanding the human cognitive architecture through evolutionary theory may provide powerful insights into the learning process. The cognitive load theory suggests that a person's ability to process information is limited and determined by the amount and type of information received [Kal09a; Kal09b; SAK11]. As information processing is a fundamental aspect of learning, this theory provides a framework for constructing more effective instructional design, as well as an explanation of why certain types of information are easier to understand than others.

A study by Pange et al. [PLT10] points out that different learning theories have different effects on students and have different effects in a computational environment when applied to different subjects. This study illustrated the complexity of this topic by showing that, in addition to learning theory, the content, structure, and nature of the course and social interactions were important factors in the learning process.

In education, such theories suggest that the meaning and understanding of the information conveyed to students do not depend solely on the content presented or the method of delivery; rather, it is the responsibility of the learners to construct meaning through their own cognitive interpretive processes [Shu01]. However, to achieve the desired learning outcomes, it is important to design instructional solutions according to learning theories [CM22].

While cognitivism, behaviorism, constructivism, theories of social interaction, and humanistic theories have long been dominant approaches to the study of learning, new approaches are emerging that incorporate or combine new and known theories. Education has been transformed by new technologies that have gained prominence in both formal and informal educational processes, adding new dimensions to pedagogy, theory, and practice [PLT10].

2.3.2. The Types of Learning

Several terms are commonly related to lifelong learning, considering that it allows learners to be as flexible as possible in their learning process, such as self-directed or self-organized learning[17]. However, there is no universally accepted definition of these terms [NS20; NP23].

Erpenbeck and Heyse [EH99] categorized them as follows [NP23]:

- **Self-directed**
  Learners have access to all given elements and components of the learning system.

- **Externally-regulated**
  Learning objectives are established by the teacher, along with operations, strategies, and control processes.

- **Self-organized**
  Learners choose and take action in an effort to increase their own professional, methodological, social, personal, and interpersonal competencies.

- **Externally-organized**
  In order to achieve self-organization goals within the learning system, a teacher assigns complex and changing learning situations that cannot be created with previous operations or strategies.

In the second half of the twentieth century, humanistic traditions in adult education promoted the notion of self-directed learning as an expression of human agency. From this point of view, it is believed that a person can be an active, energetic, free, and conscious person, choosing their own goals, directions, and patterns of behavior, rather than always being exposed to external and internal influences. The essence of learner autonomy can be seen as an expression of self-determination[18] and self-management[19]. In order to enable self-directed learning, both conditions of learner autonomy must be met [Bou12].

[17] The concept of self-directed learning is wider than but related to self-organized learning.
[18] The willingness to learn must be present.
[19] A person's ability to exercise control over the learning process.

Based on the perspectives of Harri-Augstein and Thomas [HT91], self-organized learning can be defined as the conscious and active participation of learners in their own learning. In constructive discussions with oneself and others, the learning process is observed, sought, analyzed, formulated, and reflected upon. Several benefits can be gained from this approach, including greater flexibility and creativity and a better understanding of the learning process [LJ12]. Additionally, self-organized learning is considered a central prerequisite for the development of competencies, and organizational learning is based on individual learning aimed at developing competencies, which includes both the acquisition of knowledge and the development of values. Companies that support self-organized and organizational learning are capable of acting regardless of knowledge gaps, uncertain values, and operational risks [Reg98].

2.3.3. Educational Technology

The term "educational technology" encompasses a wide range of technologies, methods, processes, and resources that can be used to enhance learning experiences in different educational settings [HSY19].

Educational technology is based on the assumption that new technologies and applications can have an impact [20] on learning. It should be noted that learning is a dynamic process and that the characteristics and functioning of educational institutions are influenced by the social, cultural, economic, and political realities and factors surrounding them. Additionally, technological developments can affect these realities by creating technological pressures on society that impact the educational practices of educators and schools [Kim19].

Educational technology research is a relatively young field, and the relationship between technology and education has been debated for almost as long as the two have existed together. Despite its questionable effectiveness, research on the subject has shifted from theory building to understanding the most effective way to implement new technologies in educational settings [KI21].

Kimmons and Irvine [KI21] identify the main topics in educational technology research from 1970 to 2020. Their results can be summarized as follows:

- **1970s:**
  Despite the young age of educational technology of these years, researchers had already begun exploring its potential. To determine the most efficient way to use technology in education, they examined many different educational methods and theories. Research focused primarily on television and other visual communication media to assess their potential use in the classroom. In addition, education technology in general has experienced rapid growth.

- **1980s:**
  Researchers have been exploring how their fields[21] might interact in order to improve

[20] Depending on the technology and application, this influence can be positive or negative.
[21] Education, technology, and psychology.

education. Despite its many challenges, research has enhanced educational technology through increased awareness and advancement.

- **1990s:**
  To date, technological advances have had the most significant impact in the field of education, with numerous debates surrounding the implementation of technology in educational settings. The research focus has been primarily on strengthening the theoretical foundations of the field, with limited investigation of new technologies. Some authors have challenged existing frameworks, while others have attempted to defend their fundamental theories to provide stronger arguments for the effective use, development, or evaluation of educational technology.

- **2000s:**
  As technology has become more ubiquitous, questions have also been asked about the impact of this new technology on learners. One such question relates to the so-called digital natives [22] and their needs. In addition, concerns have been raised about technological advances and the integration of novel resources into a classroom. As a result, this decade has witnessed a marked increase in empirical studies and tests examining technology's effectiveness in education. These years were marked by a focus on technological advances and the use of technology in education. Various studies [23] have been conducted in which researchers and educators were able to assess the impact of technology on education, leading to useful ideas for future research.

  During this period, e-learning was the most popular research topic, and a related topic was blended learning. In addition to mobile learning and educational games, Facebook was also a frequently discussed topic.

- **2010s:**
  This decade was a great time for technological advances, with mobile technology having a particularly large impact on education. As more and more people used smartphones and other mobile devices, the popularity of mobile games increased and led to significant advances in this industry. There was a growing trend of incorporating play elements into educational situations to enhance learning. This is often referred to as gamification. Furthermore, educators explored alternative methods to enhance the learning experience, such as leveraging social media platforms, and using augmented reality technology. Others were interested in teachers' adoption of technology. Therefore, the TAM received considerable attention due to several factors, including its applicability to a wide variety of contexts and examples, its ability to explain variations in usage intent or actual usage of technology, and its ease of design within

[22] People who have grown up immersed in technology.

[23] These studies includes e-learning, blended learning, digital native, learner satisfaction, technological acceptance model, environmental factors, Facebook, and integration of new technologies.

the structural equation models. The use of augmented and VR technology in education gained traction as researchers explored its potential to improve the learning process.

- **2020s:**
  The COVID-19 pandemic has required a review of education. As a result of the pandemic, schools were forced to close almost overnight and switch to a distance learning model. Around the world, these changes have presented challenges to teachers, schools, students, and their families. Furthermore, many questions about education, politics, and pedagogy still need to be addressed.

2.4. Motivation Theories

A motivated employee is a productive employee. This is a simple equation that is widely accepted and has been proven time and time again in organizations around the world. When employees are motivated, they are more likely to be committed to their work and to achieving results, which in turn leads to higher productivity and better business outcomes. Given the importance of motivation, it is not surprising that companies place such high value on it. Organizations need all the advantages they can get in today's competitive business environment, and motivated employees can give them a significant advantage.

A theoretical basis for employee motivation that facilitates understanding of this topic must be created. There have been numerous attempts to define and explain motivation in the literature.

This section addresses these topics and provides an overview of the theory behind gamification.

2.4.1. Motivation

Psychology and economic studies of motivation have provided valuable insight into why people behave in certain ways. According to research, various motivating factors can affect performance and the successful completion of tasks [Nie14; NS17b; RK12; TJ12; Wri91].

The terms "motivation" and "motives" are still used today to describe the reasons for human behavior [HS13]. For a proper understanding of the topic, an explanation of the differences between the terms is necessary. As a term, "motive" can be traced back to Latin, where motivum means reason or impulse and can be defined as the underlying reason for a specific behavior [HS13]. However, motivation can be viewed as the psychological process that describes general behavior. In addition, it is a process of establishing, controlling, and maintaining certain behaviors [RK12; TJ12; Wri91] that should not be confused with either willpower or optimism [RK12].

A thorough comprehension of motivational theories is critical to accurately predicting and understanding human behavior. With an understanding of the different types of motivational theories, a company can develop more effective strategies to motivate its employees.

2.4.2. Maslow's Theory of Human Motivation

Maslow's theory of human motivation states that the fulfillment of five fundamental needs is necessary for an individual to reach their highest level of development and realization [Mas43]. The needs identified by Maslow's theory [24] are organized hierarchically, with basic needs at the lower levels and more sophisticated needs at the upper levels. According to Maslow, each level of need must be satisfied before a person can move on to the next level. Finally, once all of these other needs are met, a person can reach self-actualization, which is the highest level of need. This is the point at which a person reaches and realizes their full potential [25] [Mas43]. Maslow's theory has been very influential in the field of psychology and has helped to shape our understanding of human motivation.

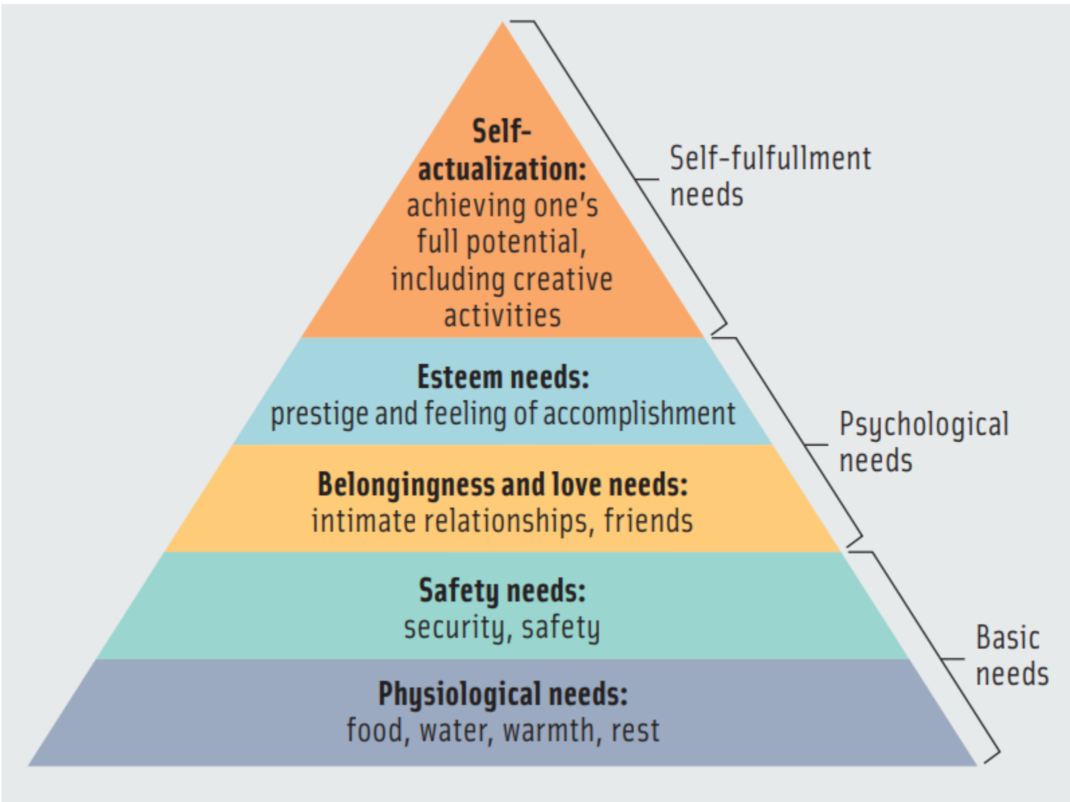


Figure 2.6.: Maslow pyramid of needs. Retrieved from Poston [Pos09]

[24] There are five basic needs according to Maslow [Mas43]: physiological needs, safety needs, social belonging, self-esteem, and self-actualization.

[25] According to Maslow [Mas43], it is the desire for self-fulfillment.

Maslow's theory of motivation has encountered widespread criticism for failing to consider the complex interrelationships between different needs and for oversimplifying the relationship between needs and motivation. However, it also achieved a high profile, so many contemporary theories of motivation make direct comparisons with his theory. According to Maslow and many contemporary studies, physiological and sociophysiological needs drive motivation. However, to the best of our knowledge, these drivers do not follow the same hierarchical order proposed by Maslow [NS17b].

2.4.3. ERG Theory

In response to the limitations of Maslow's theory, Alderfer developed the Existence, Relatedness and Growth (ERG) theory theory to reconcile the hierarchy of needs with empirical research [AB02; AG79]. This theory relates to the understanding of the factors that influence different human behaviors [Cau12]. Currently, researchers consider ERG theory to be a more valid version of Maslow's hierarchy of needs as it relates to motivation at work [AB02].

Accordingly, existence refers to physical safety needs and physiological needs, while relationship encompasses all interpersonal relationships and interactions with other people. Through growth, people can express their creativity and develop as individuals. This involves self-development, personal growth, and development [Ald72].

2.4.4. Two-Factor Motivation Theory

Two-factor motivation theory is well known in job satisfaction research. This theory assumes that there are two groups of factors in the workplace that influence job satisfaction or dissatisfaction and can be distinguished as motivators [26] and hygiene factors [27]. Motivators have a direct impact on work motivation and represent an intrinsic point of view. In contrast, the hygiene factors related to the work environment represent an extrinsic consideration [ASM17; Her03].

Herzberg [Her03], analyzed 12 studies to determine how different factors affect job attitudes. The results show that a significant influence is attributed to motivators. The findings regarding hygiene factors suggested that company policies and administration actively increased dissatisfaction in the company (see Fig. 2.7).

[26] E.g. sense of achievement, successes, recognition.
[27] E.g. salary, working conditions, interpersonal relations.

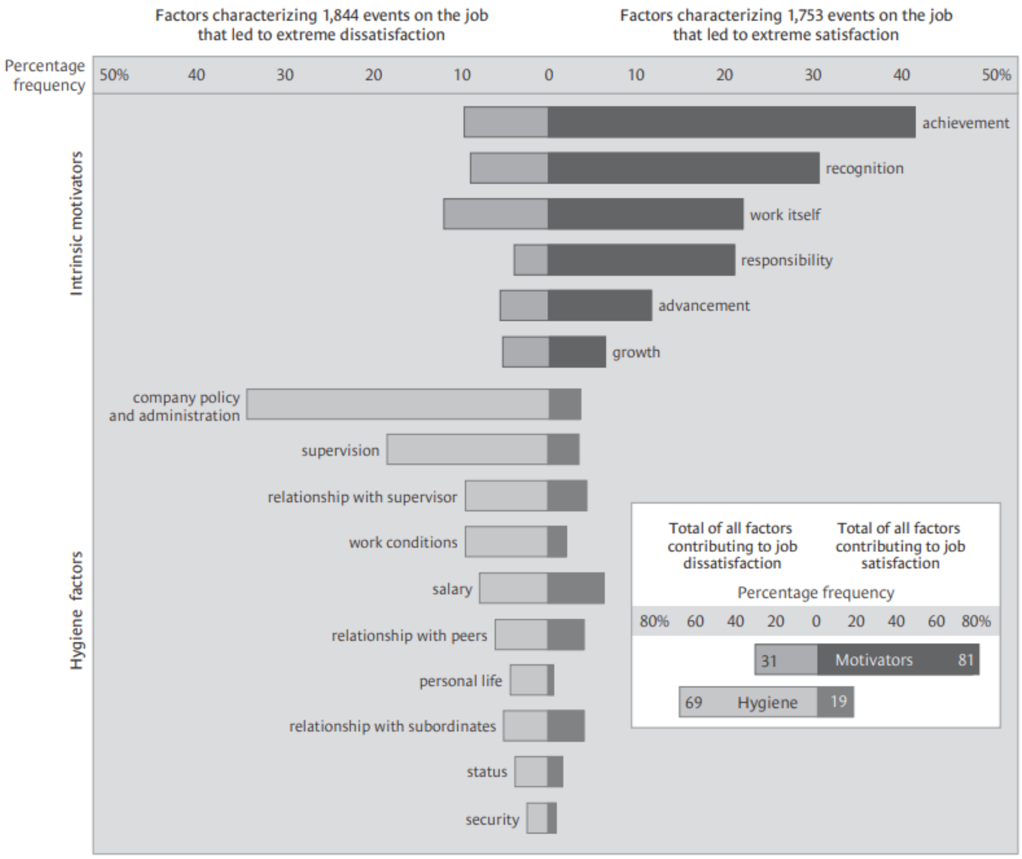


Figure 2.7.: Factors that influence work attitude. Retrieved from Herzberg [Her03]

According to Hackman and Oldham [HO76], as shown in Fig. 2.7, the primary factors of employee satisfaction are intrinsic to the work that is undertaken, while the primary causes of employee dissatisfaction are extrinsic to the work itself.

2.4.5. Self-Determination Theory

By examining the effects of external rewards on intrinsic motivation, Ryan and Deci [RD00b] explored the distinction between intrinsic and extrinsic motivation and concluded that some activities are intrinsically motivating. As a result, they developed the self-determination theory [RD00a; RD00b] and defined intrinsic and extrinsic motivation as follows:

- **Intrinsic motivation** is defined as engaging in an activity for its own sake, as opposed to being motivated by receiving external rewards. A person's intrinsic motivation indicates that a person is motivated primarily by pleasure or challenge and not by external incentives or pressure.
- **Extrinsic motivation** depicts the motivation that is present when an activity is conducted to accomplish a specific, separate goal.

Therefore, intrinsic motivation is opposed to extrinsic motivation. According to the self-determination theory, the degree of autonomy of extrinsic motivation can vary greatly [Kel10; RD00a], and it is possible to represent the types of motivation as a continuum [Han+21] (see Fig. 2.8).

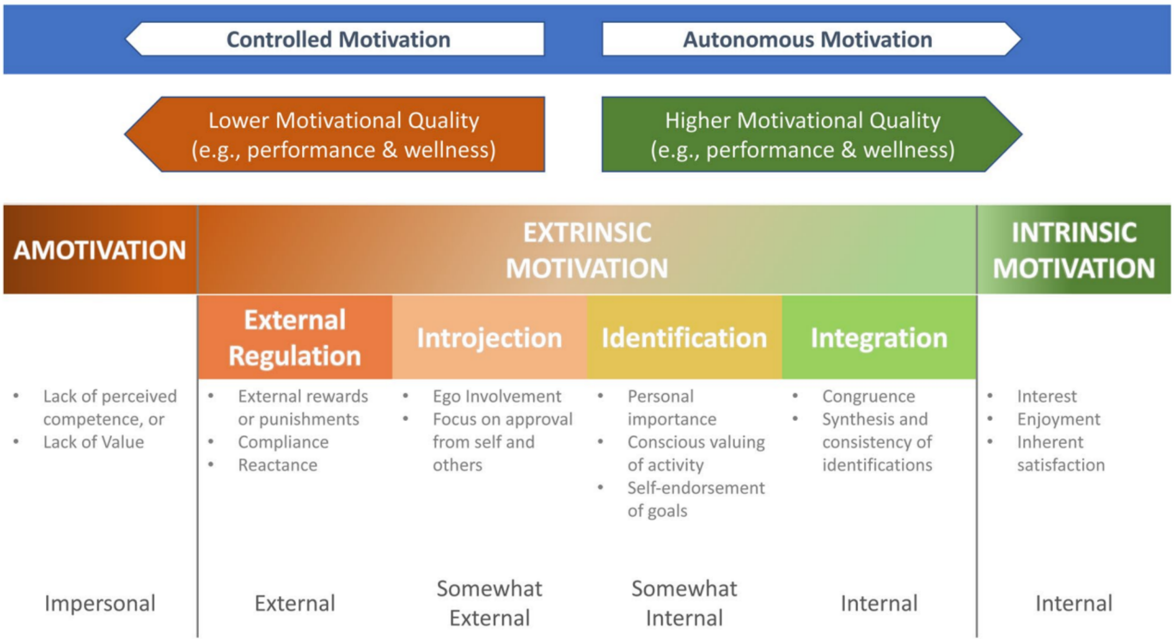


Figure 2.8.: Self-determination theory´s overview. Retrieved from Hansen et al. [Han+21]

Self-determination theory provides an empirical explanation of intrinsic motivation by identifying three main psychological needs that drive intrinsic human motivation [RD17] (see Fig. 2.9). These needs are as follows:

- **Competence** means the pursuit of competence and the attainment of proficiency to master a situation. The individual must come to terms with their own behavior and goals. Feeling empowered by being able to take direct action that leads to actual change is an important factor in empowering oneself.
- **Relatedness** refers to social connections. To maintain a sense of belonging, people desire social connections. These connections can be encouraged in an individual either by being noticed by others or by being praised for their behavior. Consequently, they feel connected and a sense of belonging to a group.
- **Autonomy:** A person's autonomy refers to the voluntary nature of their actions. The core of autonomy is being able to regulate one's own actions without relying on others. The individual must come to terms with their own behavior and goals. Independence and self-reliance are not necessarily synonymous with autonomy. In the case of extrinsic motivations, the need for autonomy and thus intrinsic motivation decreases.

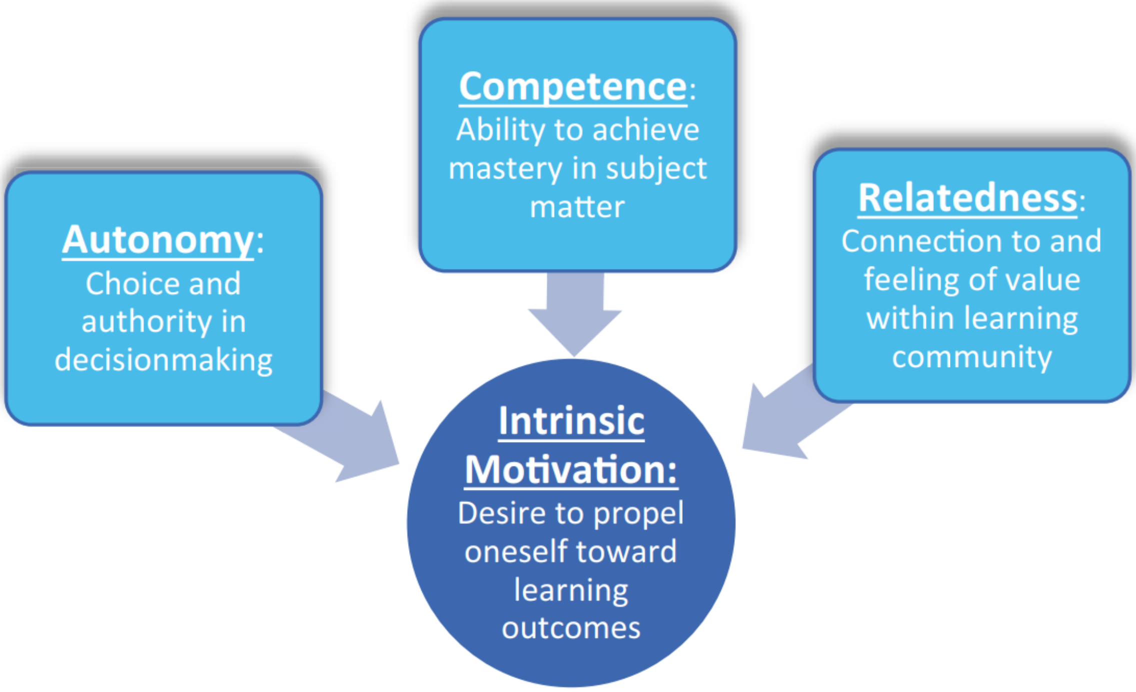


Figure 2.9.: Motivational constructs based on self-determination theory. Retrieved from Hansen et al. [Han+21]

2.4.6. Flow Theory

The importance of intrinsic motivation in an educational context cannot be underestimated, as various studies over the years have confirmed its importance as an intrinsic drive to acquire knowledge [Ame92; Anj+21; Got85; Wig+04].

Intrinsic motivation may be found in people experiencing a state of flow. According to the flow theory of the psychologist Csikszentmihalyi, a person experiencing this state is fully engaged in a task and performs at their best [NC09].

According to its original definition, flow can be understood as the holistic feeling that people experience when they are fully engaged. Furthermore, to experience flow, an individual must achieve an equilibrium between the challenges inherent in a given situation and their ability to overcome them. Such a positive state can increase motivation and engagement [Bea15]; it is experienced as an intrinsically motivated and self-rewarding state in which the perception of space and time is felt as detached from reality [CC06; NC02; Wil89].

To study the nature and conditions of enjoyment, Csikszentmihalyi studied activities that emphasized enjoyment as the primary reason for engaging in a particular activity. Consequently, to experience flow, awareness of barriers and opportunities for intervention, a clear set of proximal goals, and instant feedback on progress must be met [NC02]. Many people report that they are more likely to experience flow at work than in recreational activities [CL89].

For an experience to be optimal, there must be a balance between skill and challenge. This, in turn, results in intrinsic motivation and the best results. In contrast, when the challenge is too great compared to current abilities, it can lead to anxiety and poor performance. In addition, a lack of challenges can lead to boredom, which in turn reduces motivation. Achieving an optimal balance between the level of difficulty and the complementary skills of the individual is crucial to maximizing the experience [Bea15; Che07; CC06; NC02] (see Fig. 2.10).

The flow experience is described by Chen [Che07] as follows:

> *"During the Flow experience, we lose track of time and worries. Indeed, our level of focus maximizes our performance in and pleasurable feelings from the activity. Flow is also called the optimal experience, or being in "the Zone". Though often associated with professional athletes and artists, it is a feeling shared by every human being. Recall being so engaged in something that you forget to eat or sleep."* [Che07]

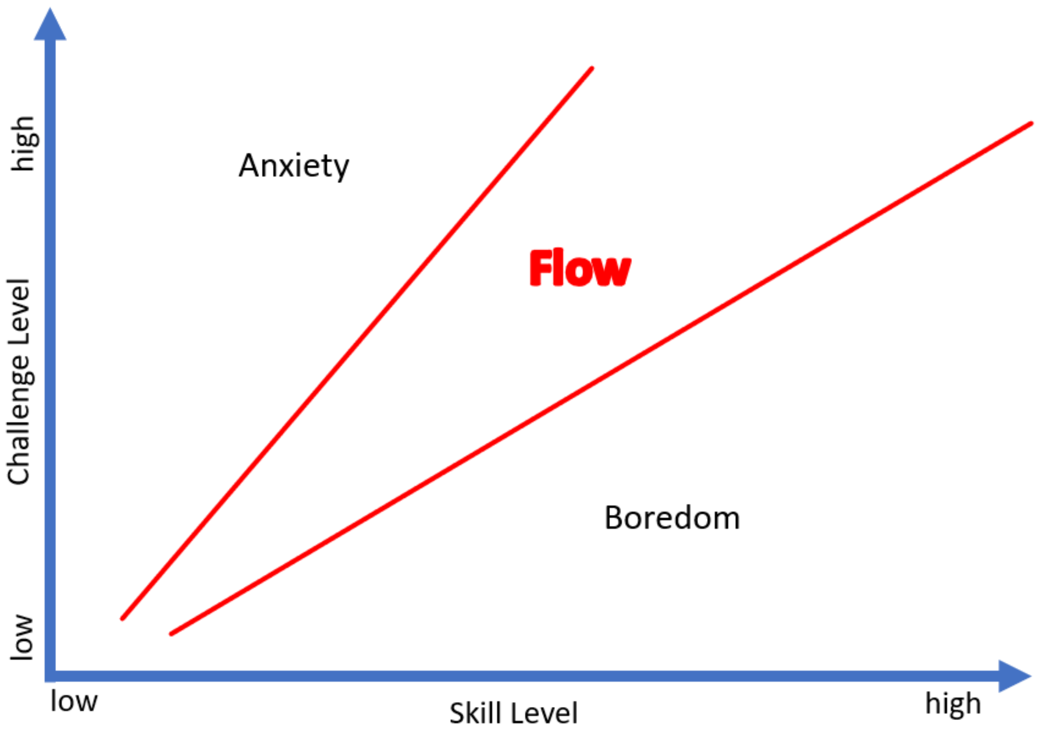


Figure 2.10.: Representation of the flow principle. Own representation based on Niermann and Schmutte [NS17a]

In addition, nine elements are related to this theory [Bea15]:

- Challenge skill balance
- Clear goals

- Unambiguous feedback
- Action awareness merging
- Concentration on the task at hand
- Sense of control
- Loss of self consciousness
- Transformation of time
- Autotelic experience

This theory can be seen an instructive and informative resource for educators [Bea15] and is commonly used in video games and gamification research [Che07; Oli+21].

2.4.7. ARCS Motivational Model

A consideration of the different factors that influence learning motivation is crucial to better understanding and improving it. According to the ARCS motivational model, four categories of variables [28] that have an impact on motivation can be identified [29] as follows [Kel87; Kel10; Kel12]:

- **Attention:** The ability to pay attention is an essential part of learning [30]. In order to motivate learners, it is necessary to develop curiosity and gain and maintain their attention. It is extremely difficult to maintain a satisfactory level of attention throughout the learning process. Therefore, the aim is to find a balance between boredom and indifference versus hyperactivity and anxiety.
- **Relevance:** At its basic level, relevance is about making connections between the instructional environment and learners' goals, learning styles, and previous experiences. The purpose of creating a relevant environment is to motivate the learner to learn, which is essential in this context [31].
- **Confidence:** Confidence is determined primarily by feelings of control and expectations of success. In addition, confidence encompasses areas of motivational research.

[28] According to Keller[Kel12], each of these major categories is further subdivided into several subcategories composed of smaller homogenous sets of concepts.
[29] Based on research into human motivation and a motivational design process compatible with traditional instructional design models.
[30] Keller [Kel87] states that attention is a prerequisite for learning.
[31] According to Keller [Kel12], relevance is also supported in this context by several other concepts, including achievement, affiliation, power, competence, flow, and authenticity. Moreover, learning can be motivated by both extrinsic demands and intrinsic desires. According to self-determination theory, it can be effective to combine extrinsic factors and intrinsic factors.

- **Satisfaction:** Learning experiences must be satisfying in order for learners to develop a continuous motivation to learn. Furthermore, accomplishments can be reinforced by both internal and external rewards. In this context, learners need to feel a sense of fairness and justice.

According to the model, these four conditions must be met for people to be and remain motivated to learn [Kel87; Kel10; Kel12].

2.5. Gamification

Increasing competition and constant market changes mean that more and more companies are changing their organizational requirements. Consequently, adaptability must become more dynamic to function efficiently, which also means that work environments are changing significantly inside and outside of the organization. There is no doubt that global projects will continue to grow, involving teams of internal and external collaborators working on individual projects or on a project basis to achieve specific goals. Without an overarching goal that ties them together, these reorganized workforce structures are unlikely to remain cohesive in the long term. It is common for companies to quickly adopt established organizational structures and patterns that do not encourage employee participation. As such, it is not uncommon for organizations to consider restructuring themselves or developing new methods to perform specific tasks to create more exciting and varied roles. Despite this, organizations are finding it increasingly difficult to motivate their employees to maintain rigid and outdated organizational structures.

This section introduces the concept of gamification, which can be used to increase productivity and playfulness and create a more engaging work environment for generations in organizations that are struggling to adopt traditional strategies.

2.5.1. Games and Play: Their Value and Importance

Play, games, and game-inspired designs have often been praised throughout history for improving the condition of mankind [ND17].

The 1980s showed that computer games had the potential ability to engage users, and consequently researchers began to look for productive uses of this technological medium and what could be applied to other fields [Mal80; Mal81; Mal82]. An example of these are business areas that constantly strive for improvement. In 1984, Coonradt wrote a book aimed at helping companies find ways to make work more enjoyable while improving engagement, productivity, and results [CN07].

This book[32] encompasses two concepts, expressed by the terms "game" and "play" that share similarities but also notable differences. Distinguishing between these two concepts is

[32]The Game of Work: How to Enjoy Work as Much as Play.

crucial to understanding their meaning and gaining a deeper understanding of gamification and its origins.

Homo ludens (man the player) is a term coined by Huizinga in 1938 to describe the urge to play as the primary drive in human life. Huizinga argued that all human culture and civilization is influenced by play, viewed as a means of learning, acquiring, and mastering skills. It can also be seen as a way to build social bonds and relationships [HNF06]. Huizinga further discusses how the definition of play changes between cultures, noting that in most modern European languages, play is defined as a voluntary, free activity that has rules and a goal. Play itself is not considered serious, but is performed seriously and is usually accompanied by a feeling of tension, excitement, or joy. Moreover, it must be viewed differently from the activities of ordinary life [HNF06; Rod06].

According to Caillois [Cai01], this concept of play does not adequately distinguish between play and game within a continuum that includes controlled (Ludus) and spontaneous (Paidia) play [BD18; ELL68].

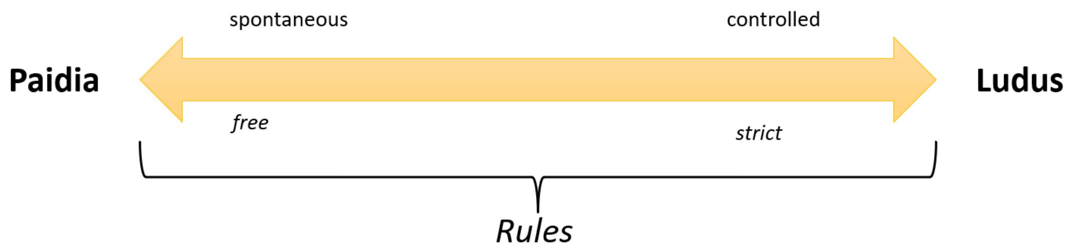


Figure 2.11.: The continuum of play and game. Own representation based on Caillois [Cai01]

Despite Caillois' exemplification and description of Ludus, which represents games with social rules [33], and that of Paidia, which refers to a form of play typical of childhood, Caillois does not provide a precise definition of these terms [34]. Moreover, the rules in Ludus define a winner and a loser, while in Paidia there are no such rules [Fra13].

Ludus employs the classical Aristotelian three-act structure, with three acts defining the interactions between participants and the stakes involved. As part of the initial act, players are introduced to the game's rules. In the following act, participants engage in a series of activities based on those rules. As a final phase, winners and losers are determined [Fra13].

From the standpoint of Salen and Zimmerman [SZ04], the terms "games" and "play" differ from each other. Games are descriptively grouped under the term play, but conceptually play is an integral part of games. In addition, these terms are both subcategories of each other [SZ04].

Salen and Zimmerman [SZ04] define a game as follows:

> *"A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome."* [SZ04]

[33] E.g., Chess, soccer, and poker.
[34] E.g., Building blocks, fantasy games, and kinetic games.

In this definition, the rules-based nature of a game is important to emphasize that people freely choose to engage in a conflict that can be resolved by following specific rules that define it. Its outcome can be measured at the end of the proposed conflict within the system. Additionally, the authors define play as follows:

> *"Play is free movement within a more rigid structure."* [SZ04]

Among the differences between games and play, one of the most important that should be recognized is that in games, an achievement or an ultimate goal can be quantified. This is what separates game from play, as play is characterized by the lack of quantifiable goals.

2.5.2. History of Gamification

The term and concept of gamification is relatively new and has gained prominence in recent years. Its origins are unclear, and various possible roots have been identified. While Deterding et al. [Det+11a] claim that gamification was first used in 2008, Werbach and Hunter [WH12] state that it was first introduced in 2003.

Although it does not have a clear origin or definition, gamification was first implemented in the second half of 2010 [BD18; ZTJ21]. Gamification has received increasing attention (see Fig. 2.12[35]), with a growing number of gamified applications emerging every year and a growing number of publications in the field [KH19].

[35] According to Google Trends [Goo22], the figure shows the search interest relative to the chart's peak worldwide since 2004. A value of 100 indicates the highest popularity for the term gamification, a value of 50 indicates half popularity, and a value of 0 indicates that for that term, insufficient data were available.

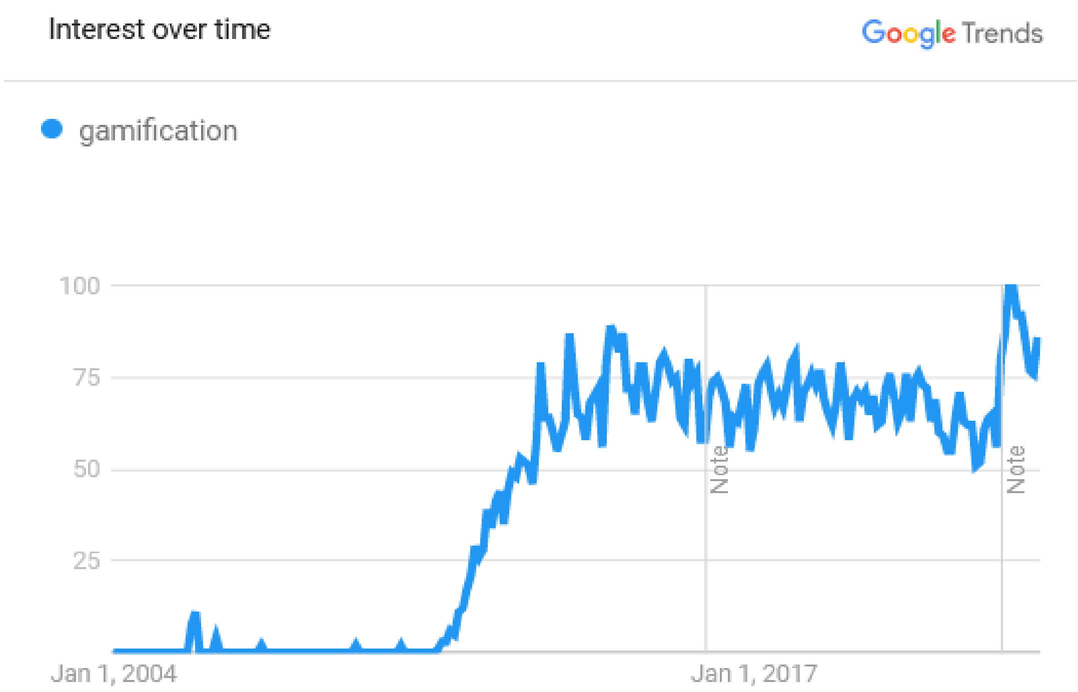


Figure 2.12.: Anonymized, categorized, and aggregated data on a large sample of actual Google searches using gamification as a search term in Google Trends. Retrieved from Google Trends [Goo22]

As part of its Technology Hype Cycle[36], Gartner [37] began to pursue gamification in 2011 [Dal14] showing its development and maturity (see Fig. 2.13).

[36]A visual representation of emerging technologies that will have a significant impact on society and business.
[37]A leading information technology research and advisory firm.

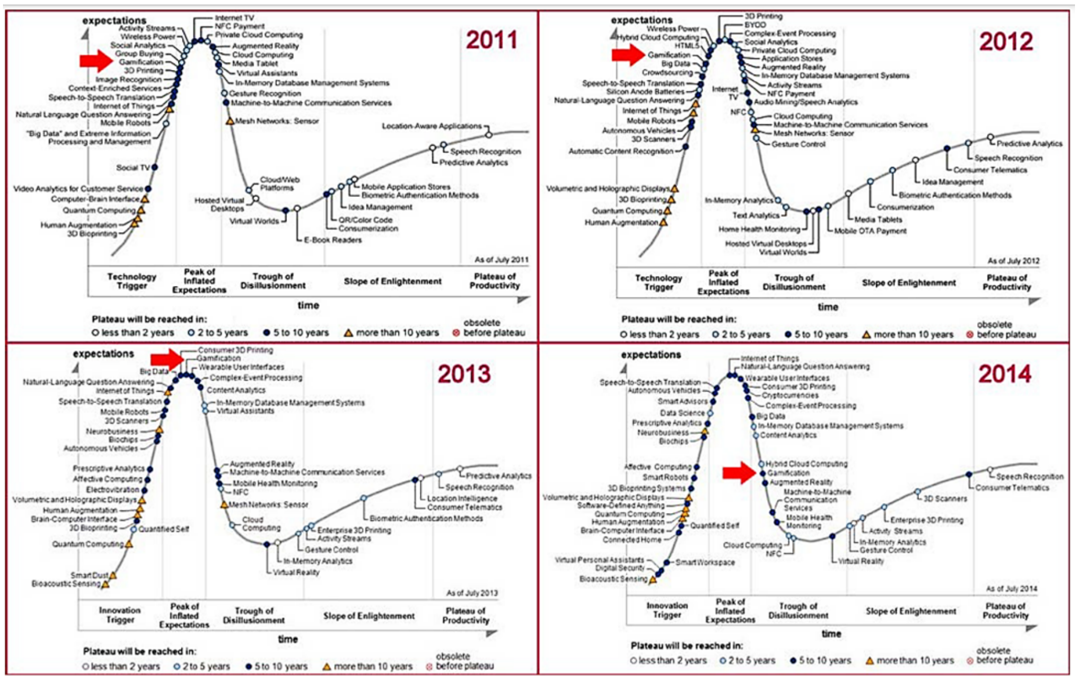


Figure 2.13.: An overview of Gartner's Hype Cycles charting the evolution of gamification from 2011 to 2014. Retrieved from Korn and Schmidt [KS15]

Currently, gamification is still maturing, gaining acceptance, beginning to crystallize [ND17], and showing itself to have potential as an effective tool for organizations. However, to ensure the success of gamification, developers need to be aware of their limitations and what gamification is [Cug13].

Although there has been research into how gamification works, its effectiveness seems to depend on both the individuals and the situation in which it is used [Det+11a] to increase engagement, commitment, enjoyment, fun, and loyalty [Cro+21; Det+11a].

In the years since it first appeared, gamification has evolved significantly and shown that it can be applied in many ways across a variety of industries with different goals. According to research, gamification can lead to desirable behavior changes [Ton+19] and has been shown to be effective in changing employee behavior in organizations in a variety of business-related situations, including corporate training programs. However, understanding the driving forces behind the adoption of gamification in the workplace remains a challenge [KMK22; Nah+19]

2.5.3. Defining Gamification

Gamification has been widely discussed in the literature and scientific publications, but it has no single definition that is accepted worldwide. Many definitions share common and characteristics, but their unique characteristics make it difficult to clearly understand what gamification is. In addition, the demarcation between gamification and other concepts influenced by the gaming industry remains problematic.

This section discusses the term gamification by examining how authors have interpreted it through different lenses.

Several definitions of gamification can be grouped into two main viewpoints from a structural and interactive perspective. Although the structural perspective of gamification is defined by the structure of the task or system, the interactive perspective underscores that gamification depends on individual cognition based on human-task interaction[Fau21].

According to a widely accepted and prominent definition of gamification provided by Deterding et al. [Det+11b], gamification is defined as follows:

"The use of game design elements in a non-game context." [Det+11b]

Gamification was first interpreted as an informal hypernym for integrating elements typically found in video games into non-gaming systems with the objective of improving user experience, involvement, and satisfaction. However, the authors emphasized the need for future research [Det+11b].

Subsequently, the definition of gamification was reframed to clarify and delineate parallel terms, and an attempt was made to define this novel concept as follows:

"The use of design elements characteristic of games in non-game contexts." [Det+11a]

Examining gamification from this point of view, the use of game design elements encourages certain behaviors and motivates one to do activities or tasks that are not directly related to games. Consequently, the concept of gamification is not restricted to the utilization of digital technology [Det+11b] but simply includes game design elements [Det+11a]. Deterding et al. [Det+11b] indicate this and do not advocate that gamification need not be limited to any particular context, purpose, situation, goal, or scenario.

Regarding this understanding of gamification, it should be noted that not every application of game design elements outside of a game context can be classified as gamification[Det+11a]. Although the digital media industry and games have inspired gamification, which borrows and applies a number of techniques from game design to engage users [Det+11b], gamification cannot be considered either gaming or games. Other experts consider gamification to be a much broader concept than Deterding et al. [Det+11a] and combine ideas previously kept separate from Deterding, such as employing full-featured games in non-game contexts or expanding the perception of game design.

According to Werbach and Hunter [WH20], gamification refers to:

"The use of game elements and game-design techniques in non-game contexts." [WH20]

This definition differs from that of Deterding et al. [Det+11a] by incorporating game design techniques. In doing so, it emphasizes the complexity of implementing successful gamification rather than reducing it to the mere use of game design elements. While gamification is not meant to produce games, it is crucial to approach it using game design principles and using a game designer's mindset to apply gamification in non-game contexts to achieve real-world goals [WH20].

In order to make gamification more malleable, Zichermann and Cunningham [ZC11] consciously combined various threads developed in games for non-gaming applications, such as serious games, advergaming, and games-for-change, in their concept. They define gamification as follows:

> *"The process of game-thinking and game mechanics to engage users and solve problems."* [ZC11]

This definition also points to the problem-solving effect of gamification and declares it to be one of its goals. Similarly, this definition of gamification has the potential to be used in any scenario that could benefit from improvements achieved through a change in human behavior and motivation [ZC11].

In 2012, Kapp proposed a concept similar to this last definition but which differs in the addition of some specifics and pointing to more goals that can be achieved with gamification. Consequently, gamification can be defined as follows:

> *"Gamification is using game-based mechanics, aesthetics, and game-thinking to engage people, motivate action, promote learning, and solve problems."* [Kap12]

In this context, gamification is not limited to creating an experience that is fun, engaging, and motivating. By adding game thinking to his definition, Kapp expands the notion of gamification by integrating and utilizing the possibilities of the psychology behind games. For Kapp, the game mechanisms and game dynamics coexist with the concept of game aesthetics in the sense of positively designed experiences. Crucially, however, acceptance of gamification is heavily influenced by the feelings players experience during the interaction.

Kapp emphasizes that several concepts behind gamification are rooted in educational psychology and emphasizes that educators have used such methods over the years to enhance learning. A good example is direct feedback, such as providing immediate corrective feedback and using point systems [Kap12]. Furthermore, Kapp argues that the difference between pedagogical practices and gamification is that gamification combines these elements to create game-like experiences.

Zichermann and Linder [ZL13] redefine gamification with a focus on business, employees, and customer engagement as a process that involves individual or group activities consisting of rules or reward structures, awarding points as a form of feedback for being engaged with the task and supporting its completion.

This definition of gamification is as follows:

> *"Implementing design concepts from games, loyalty programs, and behavioral economics to drive user engagement"* [ZL13]

According to Cardador et al. [CNW17], gamification can be defined as an incentive instrument to increase motivation and performance based on ludic techniques. This is achieved through two levers: by providing information and by improving the attractiveness of the task. According to these definitions and their structural perspective, gamification can be considered an incentive tool that achieves its results through ludic approaches [Fau21]. However, the interactive perspective of gamification asserts that a gamified system or gamified activity is designed to provide a gaming experience and emphasizes that the expected results cannot be guaranteed.

Huotari and Hamari [HH12] provided a widely used definition of gamification that supports this point of view. Their definition focuses on the user experience rather than the task or system design:

> *"A process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation."* [HH12]

Although there are multiple definitions of gamification, they seem to share common ground in the literature in terms of fundamental concepts related to games and their design, engagement, and fun. However, due to the unclear development and the wide range of interpretations of the term gamification within and outside academia [38], Marczewski [Mar21] expressed the need to redefine it, starting by questioning his previous notion of gamification as follows:

> *"The use of game design metaphors to create more game-like and engaging experiences."* [Mar18]

Part of the misperceptions appears to be caused by the etymology of -ation and -fy of the noun "gamification" and verb "gamify," which can be associated with the act of making something into a game or making it game-like. As gamification in business is often approached from a layman's perspective, Marczewski redefines "gamification" and "gamify" in a simpler way, as follows:

> *"Gamification (noun): The process of making something a game or game-like"* [Mar21]

> *"Gamify (verb): make a game or game-like"* [Mar21]

This definition of gamification can be extended by adding further detail. Marczewski illustrates it by considering the gamification of learning materials as follows:

[38] In 2014, the author of a blog post [Bur14] on Gartner's website entitled "Gartner Redefines Gamification" provides an example of it and describes how Gartner defines gamification as "the use of game mechanics and experience design to digitally engage and motivate people to achieve their goals" [Bur14]. Based on this blog post and comments from experts in the field, it is clear that regardless of how gamification is defined, there is a general recognition that it is a complex concept that is often approached in different ways.

"Gamification of learning materials: the process of making learning materials into a game or more game-like to improve users experience, participation and completion rates by using the materials in a scenario-based simulations, with deep gameplay as well as progress markers such as points and badges" [Mar21]

Agreeing with Marczewski [Mar21], Chandross [Cha21] and Velasquez [Vel21] believe that trying to define gamification is an old debate. Velasquez offered a revised definition as follows:

"Gamification is a design discipline that leverages the knowledge of game design paradigms as a core to organize knowledge around psychology, semiotics, systemics and more, to incorporate them into contexts beyond game design." [Vel21]

According to the author, this definition helps to understand the differences between schools of thought, approaches, and frameworks related to gamification.

In this dissertation, based on all the above definitions, gamification is defined as follows:

The process of making something a game, or game-like, with the goal of providing guidance and feedback through game mechanics, dynamics and aesthetics to achieve specific goals and objectives. It supports behavioral changes by motivating specific proactive and reactive behaviors within the gamified situation or application and positively impacting real-world situations.

An explanation is necessary to clearly understand this definition. This definition focuses on the outcome of gamification and its positive influence on real-world scenarios by dealing with specific or uncertain situations (proactively or reactively); thus, gamification is seen as the most appropriate method to support the achievement of specific goals outside of the game situation or application. Therefore, positive behavioral changes in real-world situations impact desired performance.

Proactive behavior addresses future conditions and involves making decisions and acting to avoid adverse outcomes by anticipating a situation before it arises. In contrast, behavior that follows in response to a past situation is called reactive behavior [GA08].

People with less experience are more likely to face unforeseen problems, be reactive, and not anticipate potential problems. However, as they gain experience of specific situations, they become better able to predict behavioral patterns, are more likely to consider more proactive actions, and recognize the consequences of their decisions and behavior [Pom+09]. Therefore, the use of gamification in the corporate context and the gamification of training applications could lead employees to gain experience and proactively encourage behavior in real-world conditions and situations to achieve the desired achievements. It should be noted that while gamification does not necessarily refer to digital technologies, it can be linked to them when used strategically.

However, the idea that combining technologies using game approaches automatically makes something more interesting and engaging is a fallacy [Cug13].

Recently, modern technologies have been used to introduce new immersive learning methods in the field of corporate training [FGL18; NP23; PK20]. The concept of XR training adopts gamification as a core element of its definition and is explained in Chapter 3.

2.5.4. Overview of Gamification Design Elements

In recent years, gamification has become an integral part of the design and implementation of various types of services and applications that aims to improve engagement, participation, enjoyment, fun, and loyalty [Cro+21; Det+11a].

As part of the process of gamifying applications, it is necessary to identify and integrate the elements of game design into those applications in order to gamify them. However, it is very important to be aware that researchers within the field of gamification are still in disagreement regarding what constitutes a game design element within gamification [Cug13].

The development of effective interactive applications has been facilitated by the principles and patterns of game design. Games and gamification not only provide a safe environment for experimentation and encourage innovation, but also facilitate learning and encourage innovation [BBG22]. Therefore, the design of all aspects of the gamified experience, from the user interface to the game mechanics, must be carefully considered in order to create a successful gamified application.

Games contain various design elements that are important to the overall player experience [AS16]. By understanding these elements and how they work together, it is possible to create more meaningful and enjoyable gamified applications. In fact, game design elements play a key role in gamification applications, which in many ways resemble game design patterns. This has led to a number of publications dealing with recurring elements used in gamification [Sai+17].

Sailer et al. [Sai+17] have classified the following elements of game design that can be easily integrated into gamification concepts:

- **Points:** Providing continuous and immediate feedback and rewards, points serve as a measure of player behavior in-game. As a result, they serve as a numerical representation of a player's progress in the gaming environment and are typically rewarded for completing certain activities within it.

- **Badges:** In the gamification environment, badges can be earned and collected based on a player's achievements. They are used to certify achievements, symbolize merit, and demonstrate a player's achievement of levels and goals.

- **Leaderboards:** Players are ranked on the leaderboards based on their relative success, therefore, helping to determine who is performing best in a particular activity.

- **Performance graphs:** These graphs provide information about a player's performance over time and do not compare the player's performance to that of other players.

- **Meaningful stories:** Unlike other game elements that provide users with feedback on their performance, the narrative context can convey a deeper level of meaning to users than other game elements.
- **Avatars:** Users can assume or create different identities within the application using avatars, which are visual representations of themselves within the game and the gamified environment.
- **Teammates:** The interactions between teammates, whether real players or non-player characters, can lead to conflict, competition, or collaboration.

These design elements are less integrated into the game functions and user experience than other game elements, making them easier to manipulate and control. Compared to other game design elements, these are less integrated into the game's functions or user experiences and are therefore easier to manipulate and control. Thus, it is possible to manipulate these elements independently, which in turn allows empirical research to determine their specific effects [Sai+17].

Fig. 2.14 illustrates the design elements used in gamification based on the review of related literature by Nah et al. [Nah+19] that support the eight gamification principles discussed in the following section.

Design Element	Description
Points	Scores to indicate progress or performance
Levels	Milestones to indicate completion of intermediate goals
Badges	Recognitions for achievement/accomplishment
Leaderboards	Listing of leading scorers and their scores
Onboarding	Aids and scaffolding to help with progress and advancement
Quest	Pursuit or journey toward a specific mission or goal
Feedback/Progress Bars	Track and display progression toward goals or sub-goals
Performance Graphs	Display performance information over time
Prizes/Rewards/Bonuses	Rewards that can take different forms
Social Engagement Loops	Reinforcements of re-engagement and calls to social events
Use of Teams	Use of social dynamics for engagement
Rules	Principles and regulations for procedure and action
Marketplace	Simulations of an economy
3D Space	3D graphic-rich environment
Avatars	Animated characters to represent different persons
Storyline (Narrative Content)	Narrative context or theme for engagement
Roleplay	Taking on specific roles or characters
Customization/Personalization	Enhance fit and relations with individuals

Figure 2.14.: Design elements and their descriptions. Retrieved from Nah et al. [Nah+19]

2.5.5. Gamification and Serious Games

When making the distinction between play and game, it becomes important to define the boundaries between gamification and serious games. Aside from the rich variety of games available today, there are also subcategories of educational games and serious games. Educational games are designed to enable the user to learn through play, while serious games are designed to achieve specific learning goals [HM18].

Moreover, as the term suggests, a serious game is a full-fledged game aimed at achieving a specific serious outcome and is not just for entertainment [Det+11a]. The subcategories of serious games are broad and include some types of educational games, simulation games, health games, news games, advergames, and games for change [WH12].

A critical analysis of the term serious games by Marsh [Mar11] reveals its problems and limitations by arguing that not all serious games can be described or characterized in terms of their game characteristics [39]. Marsh suggests that the differences should not be categorized but viewed as a continuum (see Fig 2.15).

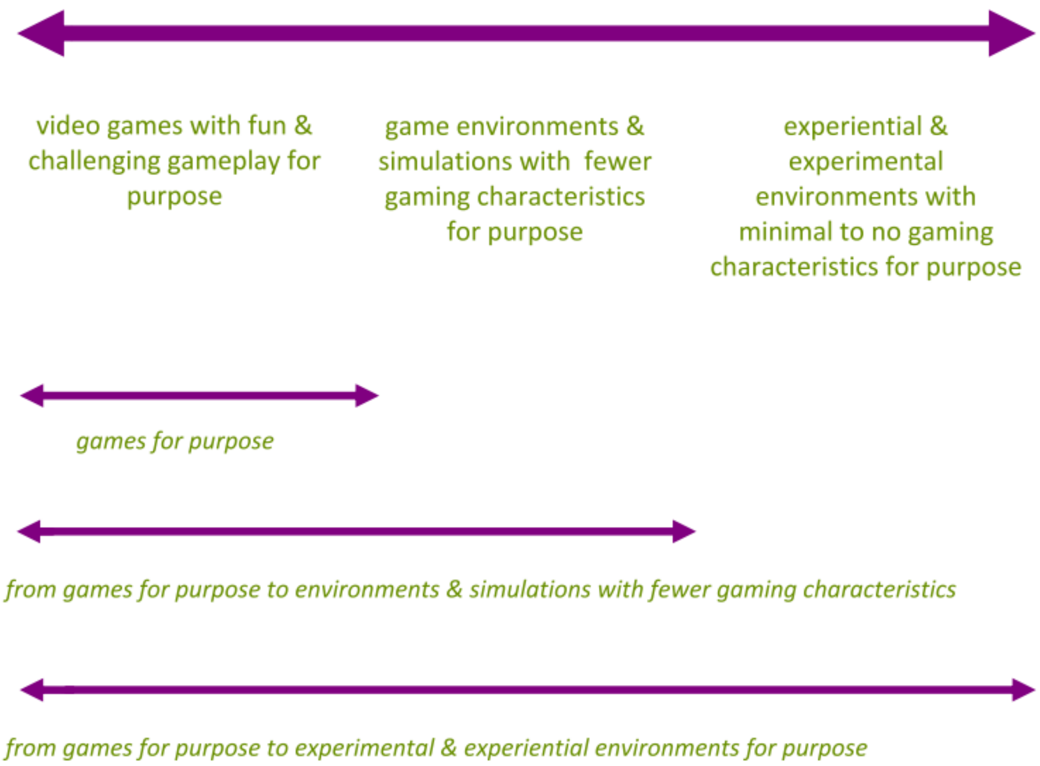


Figure 2.15.: The continuum of serious games. Retrieved from Marsh [Mar11]

[39] Challenge, fun, and play.

This continuum allows one to identify a range of serious games, encompassing their idea of what serious games are and understanding how the games relate to other serious games, environments and digital media [Mar11].

According to Deterding et al. [Det+11a], gamification can be distinguished from analogous concepts through the use of a two-dimensional (two-by-two) matrix. This matrix uses Caillois' continuum to distinguish between gaming and playing (vertical axis) and whole games and partial versions [40] thereof (horizontal axis) (see Fig. 2.16).

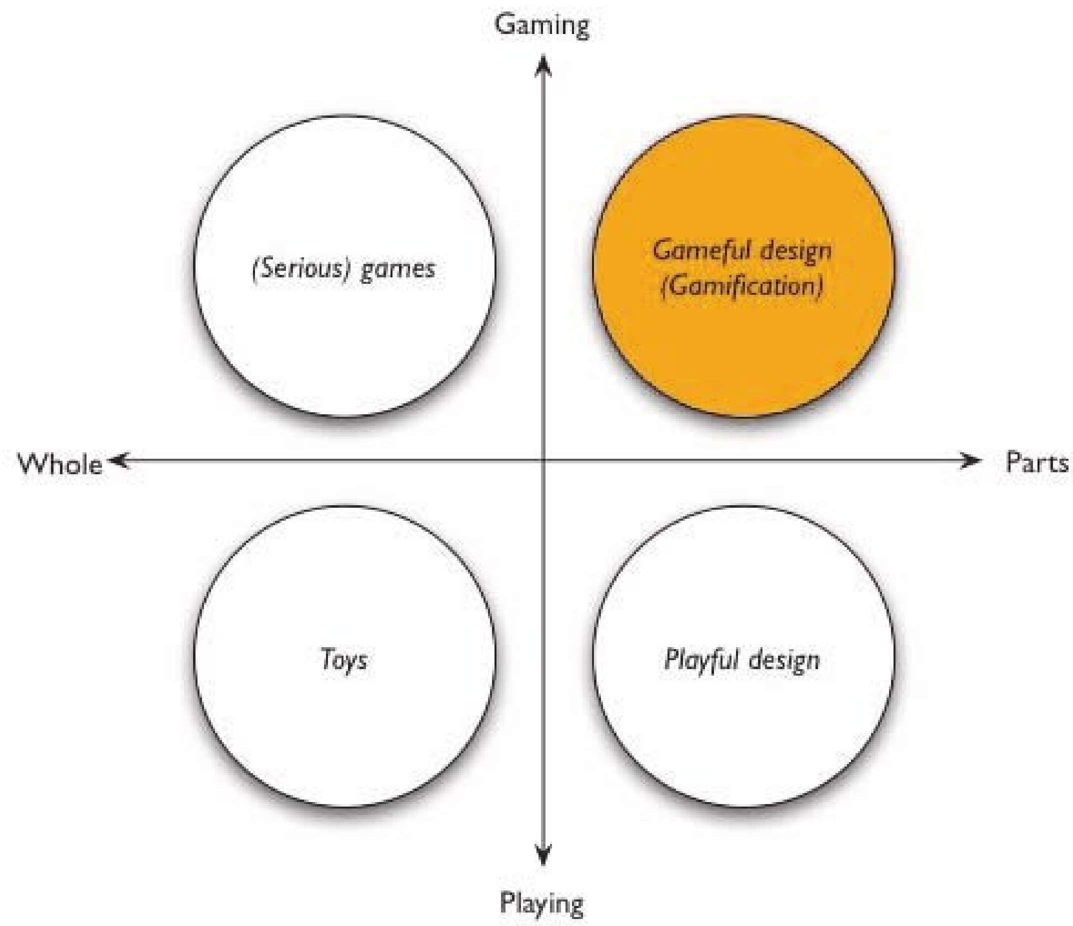


Figure 2.16.: Gamification vs serious games. Retrieved from Deterding et al. [Det+11a]

In Fig. 2.16, gamification belongs to the quadrants of gaming and partial artifacts, which means that gamification uses gameful designs and game-like elements.

[40] Partial artifacts.

2.5.6. Overview of Gamification and Design Principles

A distinction must be made between the concepts of game design and game development. According to Werbach and Hunter [WH12], the former refers to the creation and conception of a game, the latter to its technical implementation.

Salen and Zimmerman [SZ04] define game design as follows:

> *"Game design is the process by which a game designer creates a game, to be encountered by a player, from which meaningful play emerges."* [SZ04]

A game designer must not only understand the player's desires, but also know the technical feasibility and goals of the game in order to create an engaging game [WH12].

According to Werbach and Hunter [WH15], developing successful gamified applications requires an understanding of the hierarchy of game elements and suggests that it is crucial to distinguish high-level design principles, mid-level action structures, and surface-level manifestations as part of the design process. Werbach and Hunter [WH15] identify three different categories into which game elements can be classified based on its hierarchical nature (see Fig. 2.17).

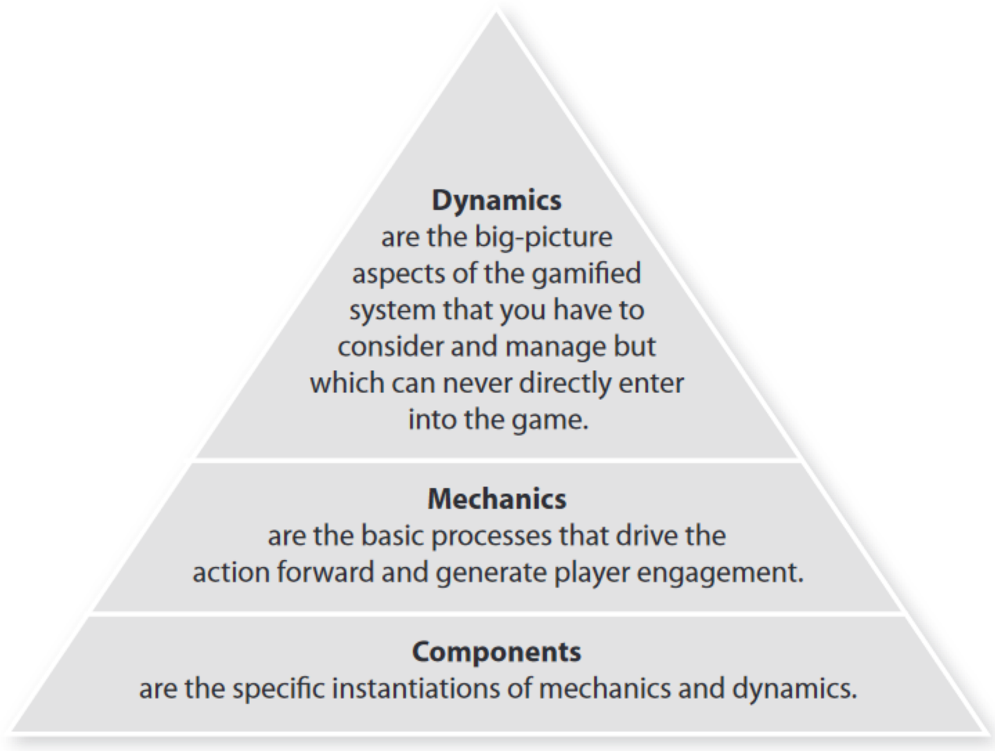


Figure 2.17.: A hierarchical view of game elements. Retrieved from Werbach and Hunter [WH12]

The chances of a successful gamification project are greatly increased by separating dynamics, mechanics, and components. Furthermore, Werbach and Hunter proposed that the creation of a gamification system should follow a top-down approach, starting with the most overarching design pattern, referred to as dynamics [WH15].

Dynamics are used to provide motivation and according to Werbach and Hunter [WH15] are as follows:

- Constraints
- Emotions
- Narrative
- Progression
- Relationships

Mechanisms drive player engagement and include the following [WH15]:

- Challenges
- Chance
- Competition
- Cooperation
- Feedback
- Resource Acquisition
- Rewards
- Transactions
- Turns
- Rewards
- Win States

As a result, mechanics manifest themselves as components that are specific examples of higher-level functionality [WH15], such as the following:

- Achievements
- Avatars
- Badges

- Boss fights
- Collections
- Combat
- Content unlocking
- Gifting
- Leaderboards
- Levels
- Points
- Content unlocking
- Quests
- Social graph
- Teams
- Virtual goods

In order to create a meaningful and immersive gamified experience, the game designer must consider the right mechanics, dynamics, and aesthetics. Here, the MDA [41] framework comes in handy. Although the MDA framework [42] originated in the gaming industry, it also has applications in the gamification industry. By formalizing the essential components of a game in terms of mechanics, dynamics, and aesthetics, and presenting their design counterparts (see Fig. 2.19), this framework makes it easier to understand the different perspectives of players and developers [HLZ04] (see Fig. 2.18).

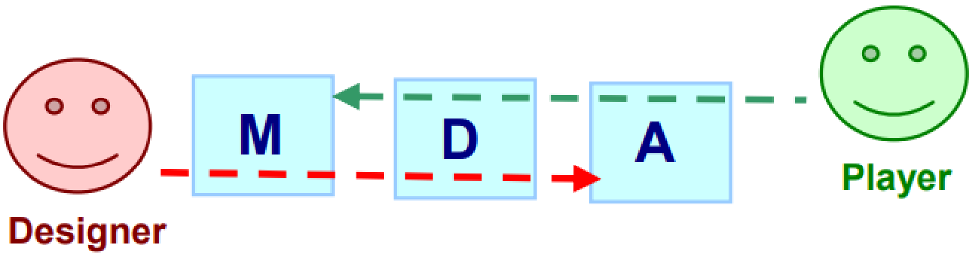


Figure 2.18.: Both the designer and the player have a different perspective. Retrieved from Hunicke et al. [HLZ04]

[41] Mechanics, dynamics, and aesthetics.
[42] The terms (mechanics, dynamics, and aesthetics) used in this framework are not equivalent to those used by Werbach and Hunter [WH12] for the game element hierarchy (mechanics, dynamics, and components).

A thorough understanding of how the components of the MDA framework work together (see Fig. 2.18) is required to develop enjoyable games and gamified applications that evoke the desired emotional responses from players. It is important to distinguish between mechanics, which detail the underlying components of a game, and dynamics, which describe how mechanics respond to player input and the output of others over the course of a game. Furthermore, aesthetics refers to the desired emotional responses evoked by the game system as a result of the player's interaction with it [HLZ04].

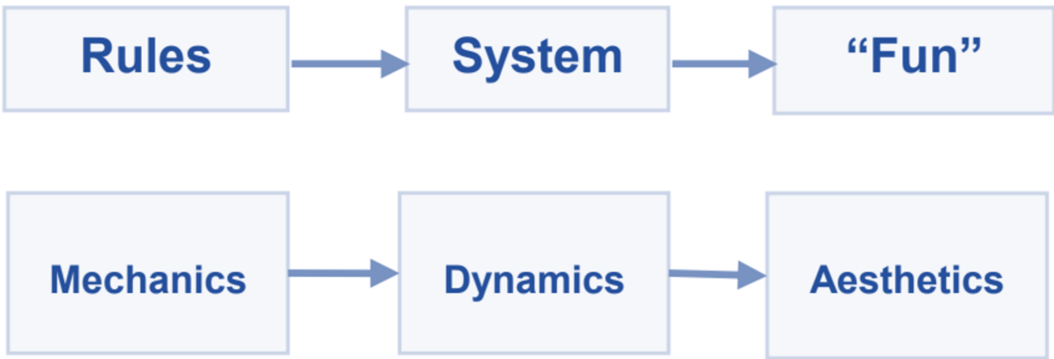


Figure 2.19.: Components of a game and their design counterparts. Retrieved from Hunicke et al. [HLZ04]

According to Zubek [Zub20], MDA differs conceptually and terminologically from contemporary design practice. Iterative design approaches a game from both ends simultaneously, although MDA's idealized model of the designer and the player are at opposite ends of the MDA chain. According to Zubek, the MDA model should be revised to reflect the iterative design process in practice.

Several factors contribute to the complexity of determining what works in gamification and how to design an effective gamification application. Furthermore, different gamification designs and implementations may prove more effective in different contexts, making it unlikely that a single solution will be effective for all individuals and groups.

According to Cugelman [Cug13], the following are the ten most popular gamification mechanics and tactics:

- Providing clear goals
- Offering a challenge
- Using levels (incremental challenges)
- Allocating points
- Showing progress

- Providing feedback
- Giving rewards
- Providing badges for achievements
- Showing the game leaders
- Giving a story or theme

Furthermore, in reviewing academic and non-academic sources of popular gamification research, Cugelman [Cug13] identified a persuasive architecture in the field of gamification. To maximize the effectiveness of gamification interventions, he recommends considering a persuasive architecture when designing.

A persuasive architecture is defined as:

> *"the optimal blend of persuasive strategies for a particular application."* [Cug13]

The persuasive architecture in gamification can be interpreted as the optimal combination of elements that are fun and engaging in a gamified application or gamified product. Adding certain core elements makes an application better, while without certain core elements, it becomes boring. Thus, Cugelman [Cug13] grouped the core elements according to how they relate directly to behavior-change strategies. These can be summarized as follows:

- **Goal setting:** Taking action to achieve a goal.
- **Capacity to overcome challenges:** The ability to grow, learn, and develop.
- **Providing feedback on performance:** Obtaining continuous feedback throughout the experience.
- **Reinforcement:** The process of gaining rewards and avoiding punishments.
- **Compare progress:** Keeping track of one's own progress and that of others.
- **Social connectivity:** The ability to interact with others.
- **Fun and playfulness:** Creating an alternative reality through play.

Based on a literature review by Nah et al. [Nah+19], the eight leading principles of gamification are defined as CIG-SCARF[43]. Each principle is outlined, with accompanying design element suggestions (see Fig. 2.20).

[43]Challenge, interactivity, goal orientation, social connectivity, competition, achievement, reinforcement, and fun orientation.

Principles of Gamification (CIG-SCARF)	Design Elements
Challenge (C)-opportunities for growth, learning, and development	Points, Levels, Badges, Leaderboards, Quest, Feedback/Progress Bars, Performance Graphs, Prizes/Rewards/Bonuses, Rules, Marketplace
Interactivity (I)-potential for immediate feedback	Points, Quest, Feedback/Progress Bars, Performance Graphs, Avatars, Roleplay
Goal Orientation (G)-setting clear and systematic goals	Points, Levels, Badges, Leaderboards, Onboarding, Prizes/Rewards/Bonuses, Customization/Personalization
Social Connectivity (S)-opportunities to interact with others	Leaderboards, Social Engagement Loops, [use of] Teams [for Collaboration], Avatars, Roleplay
Competition (C)-opportunities for social comparisons or winners to emerge	Points, Levels, Badges, Leaderboards, Quest, Feedback/Progress Bars, Prizes/Rewards/Bonuses, Rules, Marketplace
Achievement (A)-recognition of effort and/or accomplishment	Points, Levels, Badges, Leaderboards, Feedback/Progress Bars, Performance Graphs, Prizes/Rewards/Bonuses
Reinforcement (R)-structure of rewards based on performance	Levels, Badges, Leaderboards, Onboarding, Feedback/Progress Bars, Prizes/Rewards/Bonuses
Fun Orientation (F)-creating interest, curiosity, and enjoyment	Quest, Prizes/Rewards/Bonuses, Rules, Marketplace, 3D Space, Avatars, Storyline (Narrative Content), Roleplay, Customization/Personalization

Figure 2.20.: The eight leading principles of gamification. Retrieved from Nah et al. [Nah+19]

2.5.7. Challenges in Integrating Gamification

Despite the fact that gamification has garnered attention in a variety of areas, evidence of its effectiveness is still lacking, as different topics, contexts, applications, user bases, and communities seem to perceive its impact differently [Cug13].

Although the introduction of gamification offers potential rewards, it also comes with unique challenges. In addition, there are several complexities to consider when implementing and integrating a gamified system.

In this context, the adoption and use of these technologies must take into account that the use of digital technologies and digital games is likely to be influenced by demographic differences. However, current research results indicate that the processes of adopting and using technology are significantly influenced by age and gender, as well as by differences in perception, motivation, and information processing. In relation to gamification, both age and gender represent perspectives on games and gameplay that have long been largely ignored by industry and academic circles alike [KH14].

Studies about gamification have shown varying degrees of positive and negative effects. Furthermore, a large body of anecdotal evidence on gamification in business has been generated through case studies and industry claims, and due to its promotional value, researchers have intensified their studies and are keen to investigate more thoroughly [Cug13].

As much as gamification has become a popular trend, the question of its effectiveness still remains.

According to Cugelman [Cug13], the effectiveness of gamification and gamified technology is determined by whether it leads to lasting and sustainable changes in beliefs, attitudes, and behaviors over time [Cug13].

A systematic review of the literature conducted by Hamari et al. [HKS14] shows that gamification can lead to positive psychological and physical outcomes, making applications more engaging and enjoyable. Despite its positive attributes, gamification as a voluntary activity remains associated with negative interpretations of manipulation or exploitation [PN21].

Recently, there has been some debate about the ethical validity of gamification. One of the most common arguments against gamification relates to its use for various business purposes and claims that it exploits employees for the benefit of employers. This has led to a number of ethical debates about gamification and raised many ethical questions. Moreover, as the gamification community is aware of moral issues and is trying to address them, it is essential to create a code of ethics [Kim18].

In summary, as gamification and immersive technologies become more prevalent and popular, ethical concerns also increase [PN21]. Despite the many benefits that can come from using gamification, it is imperative to consider its impact on individuals and society as a whole. Consequently, a deeper understanding of gamification and the associated ethical implications is required. This allows people to make informed decisions about how best to integrate and implement gamification to create gamified systems that use technologies such as XR.

2.6. Video Games

Today, video games are an integral part of our society and come in various formats, from simple games that can be played on handheld devices to sophisticated VR headsets. They are enjoyed by people of all ages, from young children to adults, and they provide a unique form of entertainment that can be both stimulating and relaxing. Furthermore, the added benefits of playing video games allows them to surpass consideration as just a form of entertainment and to find application in various fields, such as education, training, and even healthcare. From improving cognitive abilities to promoting social interaction, video games are used in a variety of ways to enhance our lives, and one of the most promising uses of video games is their ability to serve as a learning tool. With their interactive and engaging nature, video games have the potential to teach players and also to be used to promote physical activity and healthy lifestyle choices. As our society evolves and research continues to explore the potential of video games, video games are likely to become more prevalent and important.

This section explores various topics that are relevant to video games and related to gamification and XR training. Some of them were extracted, adapted, and extended from Palmas et al. [PRK21] and Palmas and Klinker [PK21].

2.6.1. Video Game Market

Over the past few decades, the video game industry has experienced significant growth [PRK21; Wal20]. The video game market is now the largest within digital media [Lin21; Wal20] and is among the most profitable entertainment industries [Ric20] (see Fig. 2.22).

Furthermore, global video game sales are forecast to grow from $155 billion in 2021 to $240 billion in 2026 [44] [Lin21] (see Fig. 2.21).

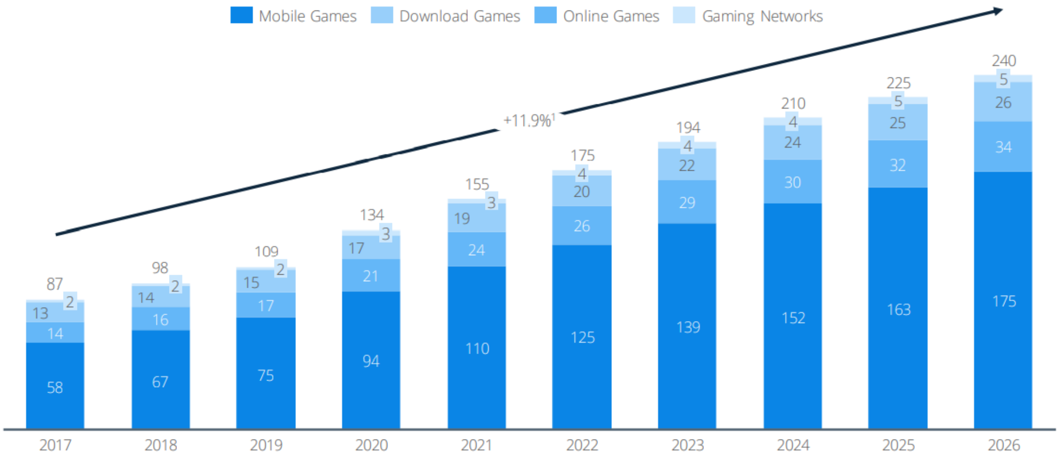


Figure 2.21.: Forecast of global video game revenue in billions of dollars. Retrieved from Statista [Lin21]

Perhaps the most influential factors supporting this growth are widespread digitalization, the accessibility of computing devices, and the ubiquity of the internet, which have made it easier for individuals to play video games at any time [PRK21]. Other factors may include the development of new genres of games [FP18], as well as the affordability and increased appeal of the technical features of consoles. These factors in particular have enabled game development studios, publishers, and independent developers to reach more consumers than ever before, thus increasing the commercial value of games [PRK21].

[44] According to Statista [Lin21], the video game segment growth rates average is 11.9% per year.

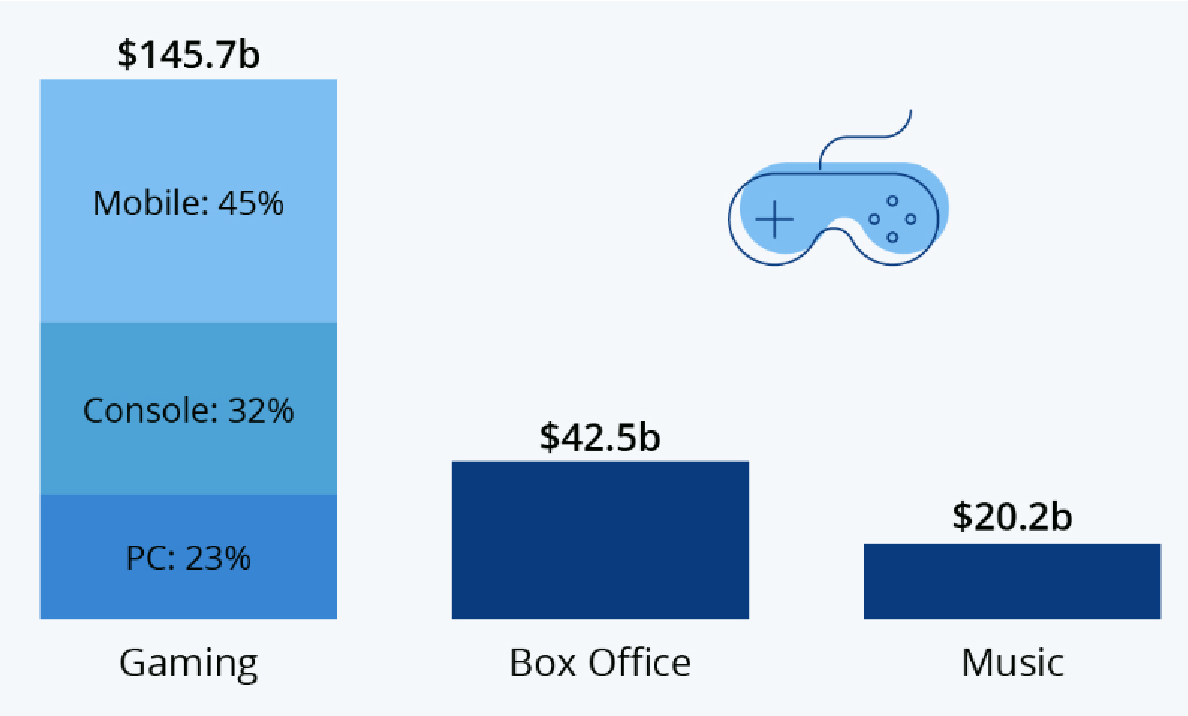


Figure 2.22.: Revenues of selected sectors of the entertainment industry worldwide in 2019. Retrieved from Statista [Ric20]

The advent of technological advances in devices and platforms used for video gaming, both online and offline, has led to the emergence of various novel business models surrounding video games. This led to and facilitated the expansion of their reach and attracted an ever-growing number of players [Lin21; PRK21] (see Fig. 2.23). Furthermore, mobile gaming has gained popularity along with esports in recent years [Lin21].

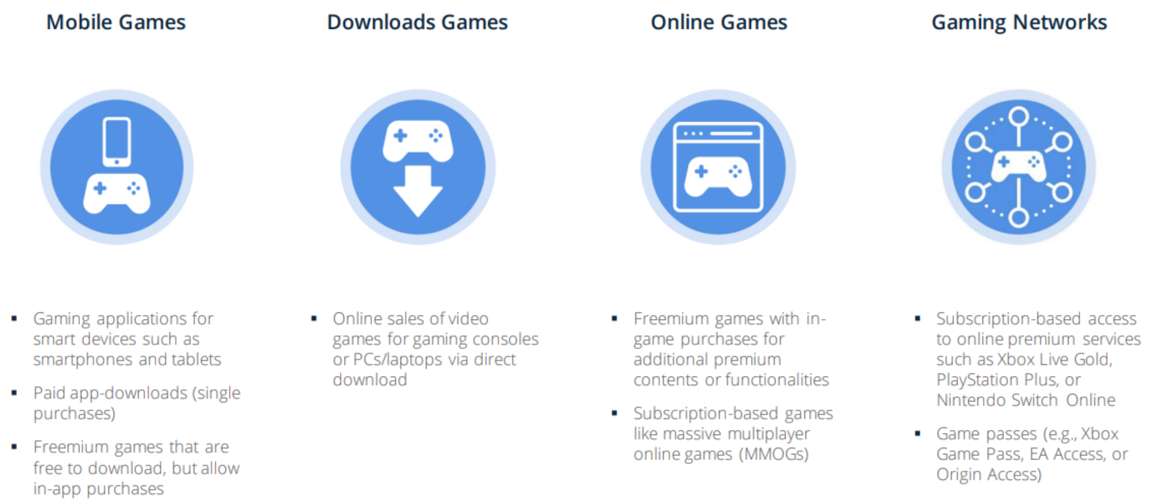


Figure 2.23.: Overview of the video game digital market. Retrieved from Statista [Lin21]

During the pandemic, the video game industry has thrived and flourished. The shutdown due to the pandemic caused many people to stay at home and rely on video games for entertainment, resulting in an increase in the number of people playing video games [Lin21; PRK21]. The effects of the pandemic are likely to have a lasting impact on the industry (see Fig. 2.24), as new players may be willing to continue playing even after the pandemic has passed.

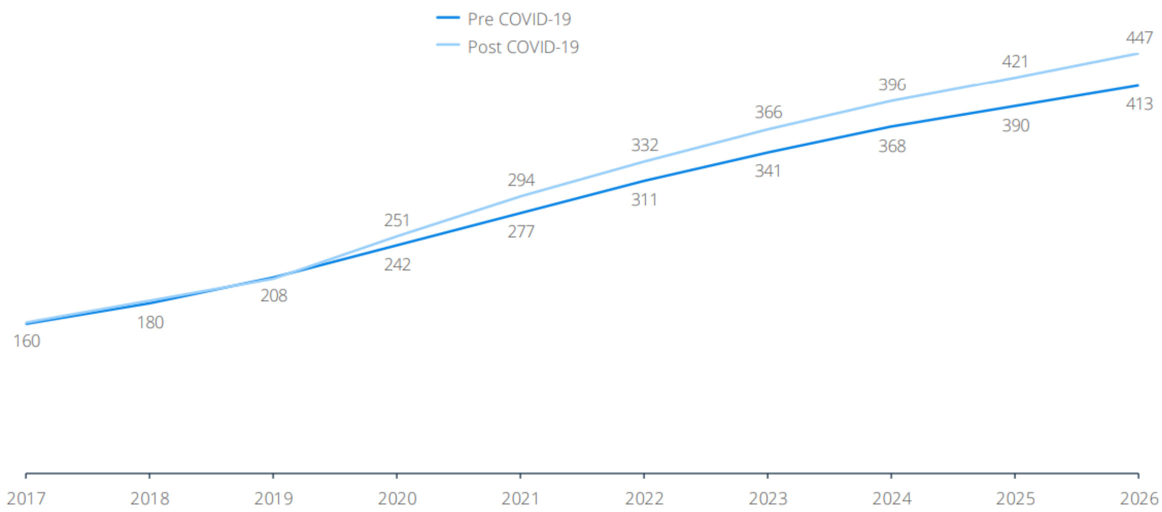


Figure 2.24.: The impact of the Coronavirus on the global digital media revenue forecast. Retrieved from Statista [Lin21].

Although video games have existed for decades, only in recent years have they began to be taken seriously as a form of entertainment [Fro03; Poo04]. The gaming sector is still evolving, as evidenced by the increasing popularity of streaming services that allow viewers to watch others play video games, suggesting that many people now prefer to watch rather than participate in games [PRK21; PK21]. In this context, an industry that has developed around video games is esports, which commonly refers to professional- and amateur-level competitive video gaming. Esports are structured similarly to real-life sports, with teams of players competing against each other in tournaments and leagues [Cra+21; HS17; MHD18]. The global esports market generated just over 950 million U.S. dollars in revenue in 2020, and it is expected to grow rapidly over the next few years (see Fig. 2.25). A driving force behind this growth could include factors such as increased sponsorship investment and digital advertising [Sta21d; Sta21a], as well as the popularity of streaming services such as Twitch and YouTube Gaming [Sta21c].

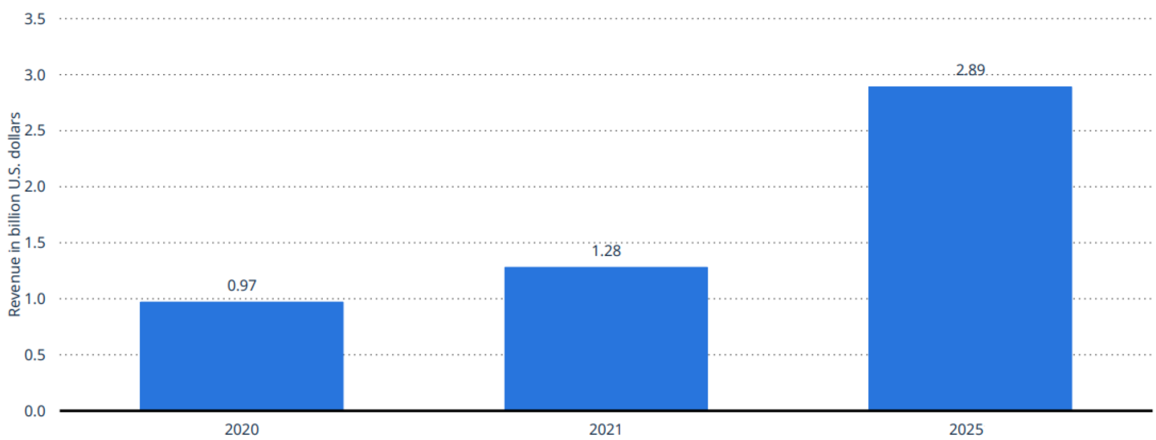


Figure 2.25.: Estimation of the size of the global esports market from 2020 to 2025 in billions of dollars. Retrieved from Statista [Sta21a]

In conclusion, the gaming industry has become lucrative and is here to stay.

2.6.2. Business Models and In-Games Advertising

Over the past few decades, the video game industry has evolved into a dynamic, promising industry that offers new business opportunities and involves new advertising strategies aimed at reaching a wide audience of gamers of different ages and genders [PK21].

As a result of the democratization of game development, emerging new business and monetization models, digital distribution models [Sta21b] (see Fig. 2.26), game production studios, publishers, and independent game developers are increasingly finding it possible to reach their consumers directly [PK21].

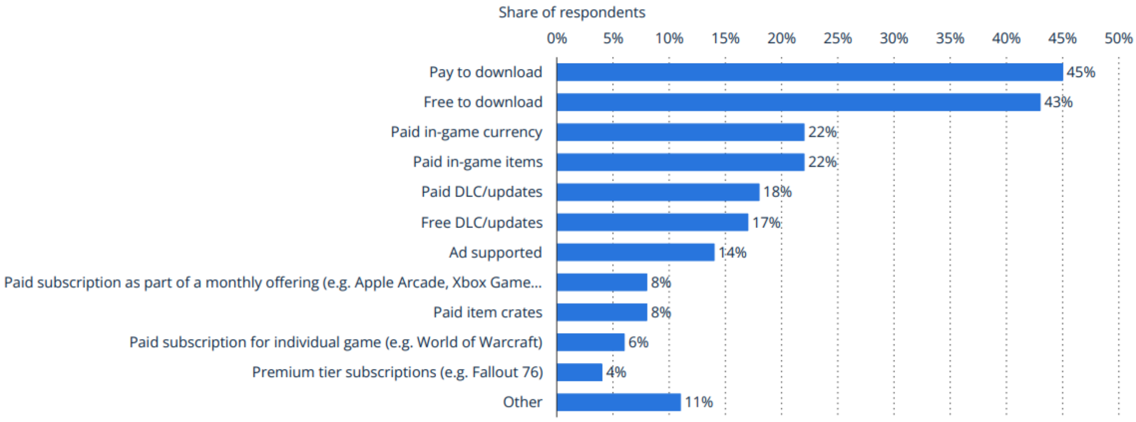


Figure 2.26.: The most popular business models used by video game developers worldwide in 2020 based on 4.000 respondents. Retrieved from Statista [Sta21b]

Different genres and platforms of video games have different monetization methods. For example, for games that are free to play, digital content is sold or a freemium business model is used. With the freemium model, some parts of the software are available for free, but additional features must be purchased [Mel+21]. Furthermore, this type of games generates revenue from direct monetization [45] or through indirect monetization [46] [PK21].

In addition, video games offer a unique opportunity for brands to communicate their values and promote products in a new and interactive way. Advertisers can reach a defined audience through in-game advertising formats and the placement of these formats within a game [PK21; PRK21].

According to Palmas and Klinker [PK21], in-game advertising can be considered either static or dynamic and applied in different ways, such as the following [PK21]:

- Billboards and banners advertisements
- Interstitial ads [47]
- Rewarded ads [48]
- Playable ads [49]
- Offerwalls [50]

[45]The users that have to purchase additional in-game content to continue playing.
[46]Revenue comes from sources other than users.
[47]Various advertisements displayed between video game activities, e.g., video commercial breaks.
[48]Ads that reward after completing them and allow for in-game rewards.
[49]Interactive minigames designed to serve as teasers of other games.
[50]Offerwalls, which prompt users to select an offer within an in-game storefront-like interface, which subsequently induce users to take a specific action (e.g. engage with marketing content) in order to receive in-game currency earn or progress further in the game.

- Product placement [51]

2.6.3. The Efficacy of Video Games

Video games have been recognized by the academic world in the interdisciplinary field of games studies. Games studies encompass an ontological analysis of video games, as well as their socio-cultural impact and applications outside of entertainment [NH08; Mäy08]. An important aspect of video games is their potential for positive societal impact. For instance, video game elements and mechanics are applicable in other fields such as learning, corporate and XR training, and inspiring the creation of entirely new concepts (e.g. gamification) [PK21].

In this way, the video games industry contributes not only to entertainment, but also to progress ,in other areas. Therefore, it is evident that this industry is a thriving sector that has much to offer to both society and individuals [MVG15; PK21; Squ06].

The video games played in the early stages of the COVID-19 pandemic had multiple impacts on people. The effects of gaming on stress, anxiety, depression, loneliness, and gaming disorders were discussed in a recent systematic review. The results suggest that video games, especially online multiplayer and AR games, alleviate stress, anxiety, depression, and loneliness in young people during periods of confinement. However, for at-risk individuals [52], playing video games can negatively impact stress, anxiety, depression, loneliness, and symptoms of gaming disorder [PPM22].

Video games are not only an entertainment medium, but have also attracted attention for their learning application capabilities [PK21]. Several positive outcomes have been associated with video games [GLE14; Gra15; Gra18; MS04] in several fields, including education, health [Kat+08], psychological and physical therapy [Tay+18], memory [MBG12] and cognitive development [GLE14; PFM18].

However, some people argue that video games produce negative impacts [GLE14]. Furthermore, it is claimed that video games are a waste of time [Lee21; SHC17], that they are addictive [BJ06], and that they can lead to violence [DD98; Web+20]. Others argue that video games can be used as a tool for learning [AM03; GLE14; OWB05; PK21; Squ06] with some studies showing that video games have certain positive effects on people, such as improving related visual skills [Rie04], hand-eye coordination [Gri+83], problem-solving skills [Rug14],and cognitive and decision-making skills [Rey+21]. Furthermore, in a recent study by Sauce et al. [Sau+22], gaming showed positive effects on the development of intelligence in children and that appeared to be causally related.

However, the debate on the benefits of gaming is still open, and more research is needed to better understand gaming's potential and its positive and negative effects.

[51] Proper placement of digital products within the game environment.

[52] According to this research, they are particularly young people, mostly males.

2.6.4. Contextualizing Motivation Theories

Several video games offer a single, static, tight experience without considering that each player has different skills and expectations and experiences different flow zones [Che07] (see Fig. 2.27).

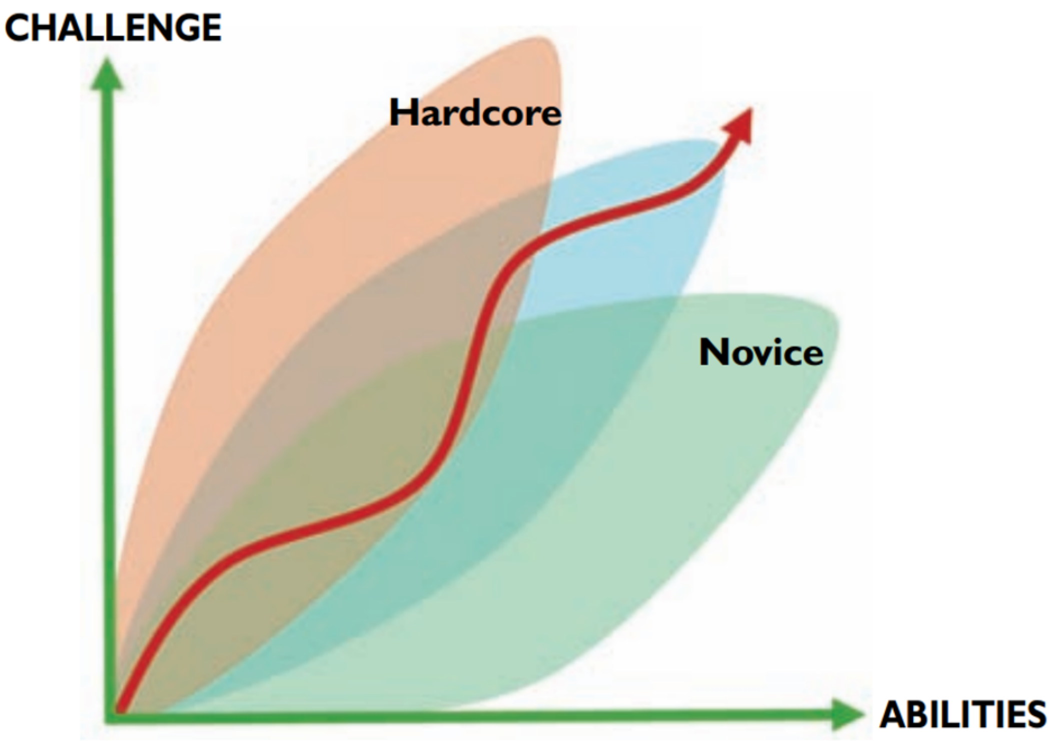


Figure 2.27.: Flow zones differ between different players. Retrieved from Chen [Che07]

In addition, a one-size-fits-all approach is not the most effective way to create an interactive experience that caters to a broad audience. Instead, the design should offer users a variety of options, allowing them to enjoy a personalized experience that suits their unique needs and interests. However, the process is complicated and expensive [Che07].

Furthermore, providing more and more choices to improve the immersive experience has its drawbacks. An abundance of choices can leave people feeling overwhelmed and confused, as well as having trouble maintaining a sense of flow. In terms of design, it is crucial that the number of choices offered in a game is carefully considered [Che07] (see Fig. 2.28).

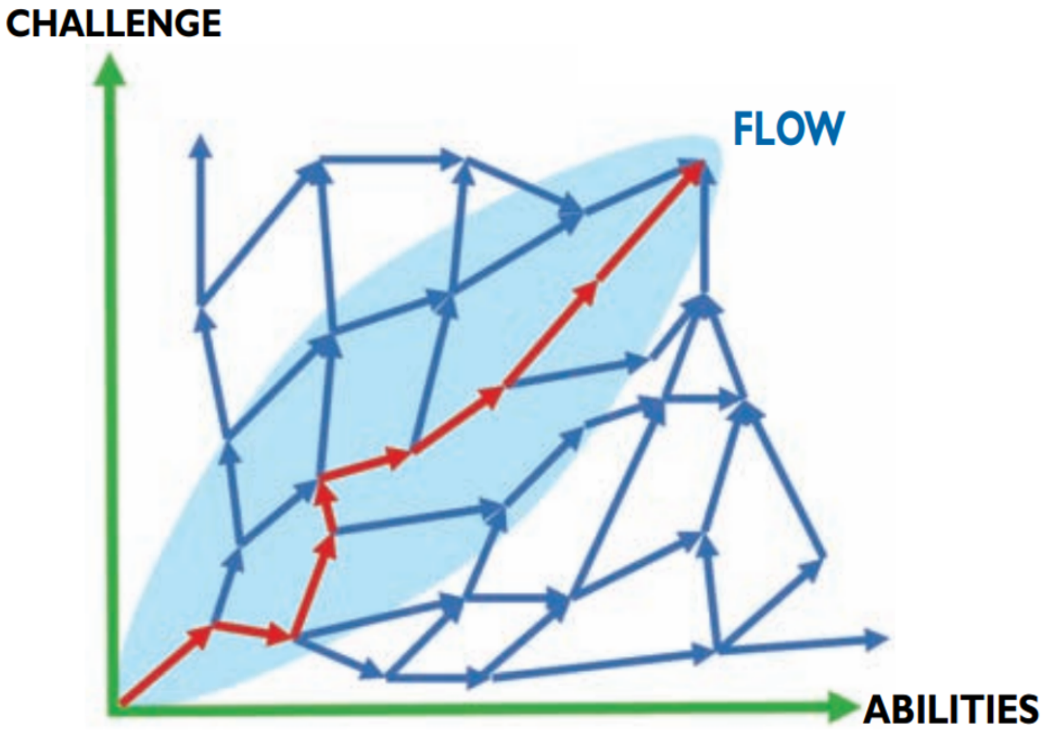


Figure 2.28.: Flow experiences are shaped by the choices designers build into the experience. Retrieved from Chen [Che07]

Achieving and maintaining a state of flow can be compared to twisting and turning (see Fig. 2.29), as each step introduces a cycle between stages that increases in difficulty as the player's skill increases in quantified increments of time.

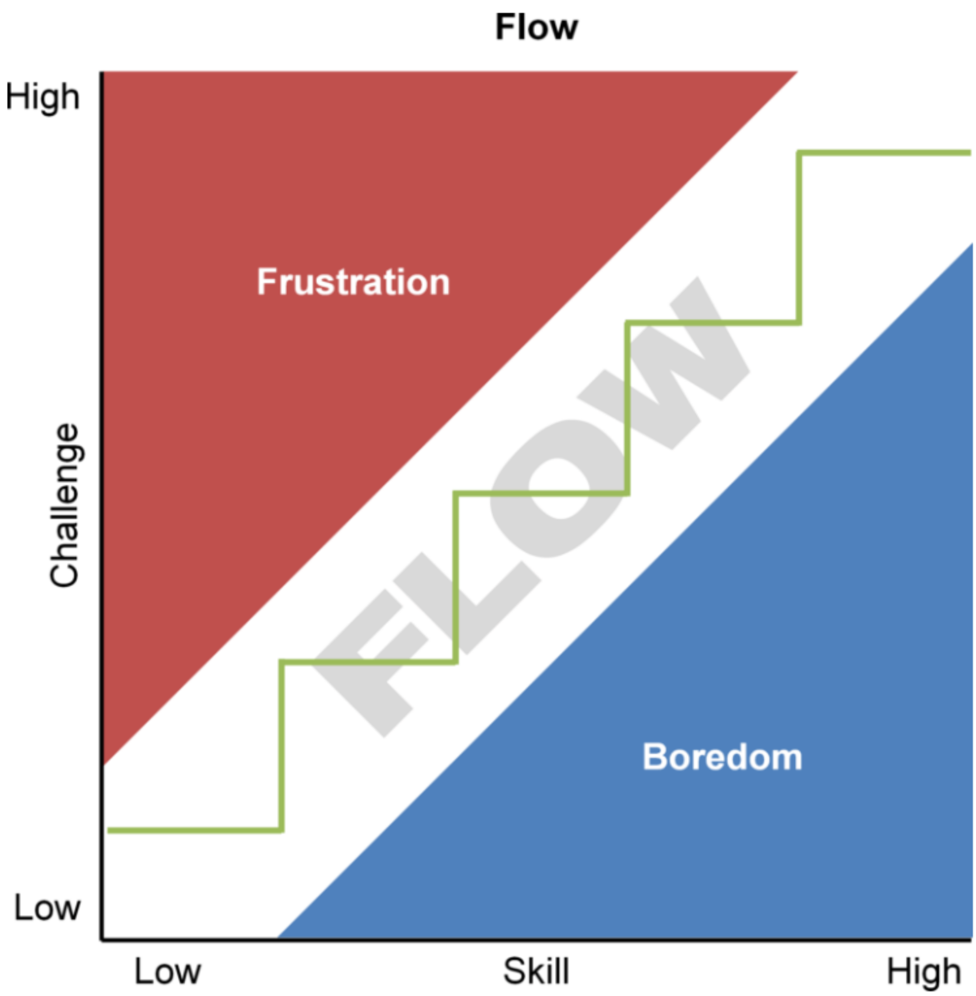


Figure 2.29.: Ideal flow in game design and gamification. Retrieved from Marczewski [Mar15]

It is important to note that in games, each step of this process to reach and maintain the flow state involves a transition between the following phases [Mar15] (see Fig. 2.32):

- **Grinding:** Players face challenges to develop their skills and gain experience. These challenges are designed not to require a high level of skill and are not time consuming.
- **Levelling:** As players' skill levels increase, challenges tend to become harder.
- **Mastering:** To be able to successfully complete the challenges put before them, players must be challenged according to their skill level.
- **Testing:** Testing is crucial for players to identify gaps in their skills and to acknowledge that their current skills are insufficient to complete the challenges.

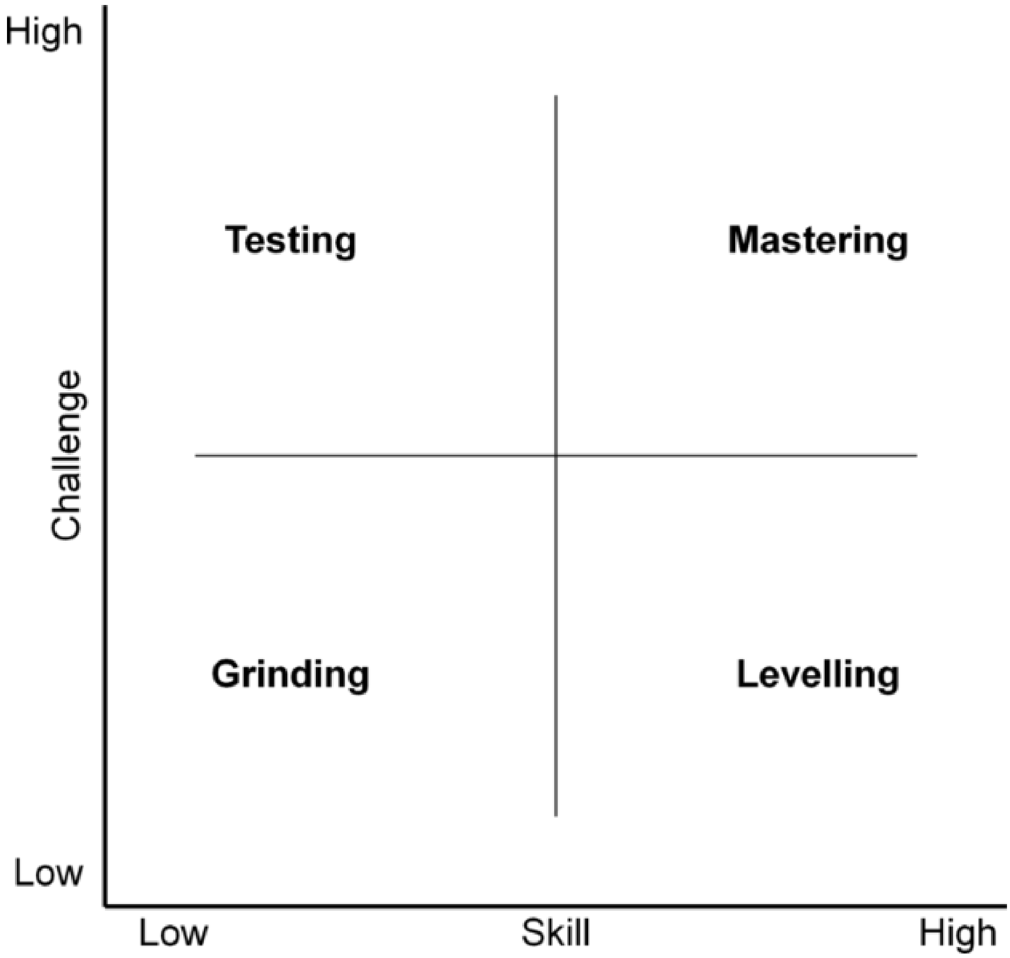


Figure 2.30.: The four distinct phases from grinding to mastering. Retrieved from Marczewski [Mar15]

There are three different cycles, which can be categorized as follows [Mar15] (see Fig. 2.31):

- **Grinding:** The grinding phase is initiated by the user. As the user gains experience, they become bored and move up a level. In this way, the leveling phase begins, and the player is challenged to match their skill level, which leads to the mastering phase. Upon completion of the mastering phase, the player is faced with considerably more challenging tasks, so the person returns to the grinding phase.
- **Challenging:** All four phases are included in this cycle. Rather than the mastering phase being followed by the grinding phase, users are challenged at a level higher than their skills. This can be considered as a test or a "boss battle". The player may become frustrated if they cannot complete the challenge. Compared to mastering, a greater sense of accomplishment and reward is achieved by succeeding.

- **Mastering:** There is no grinding phase in the mastering cycle. In the leveling phase that follows the testing phase, the challenges become immediately more difficult.

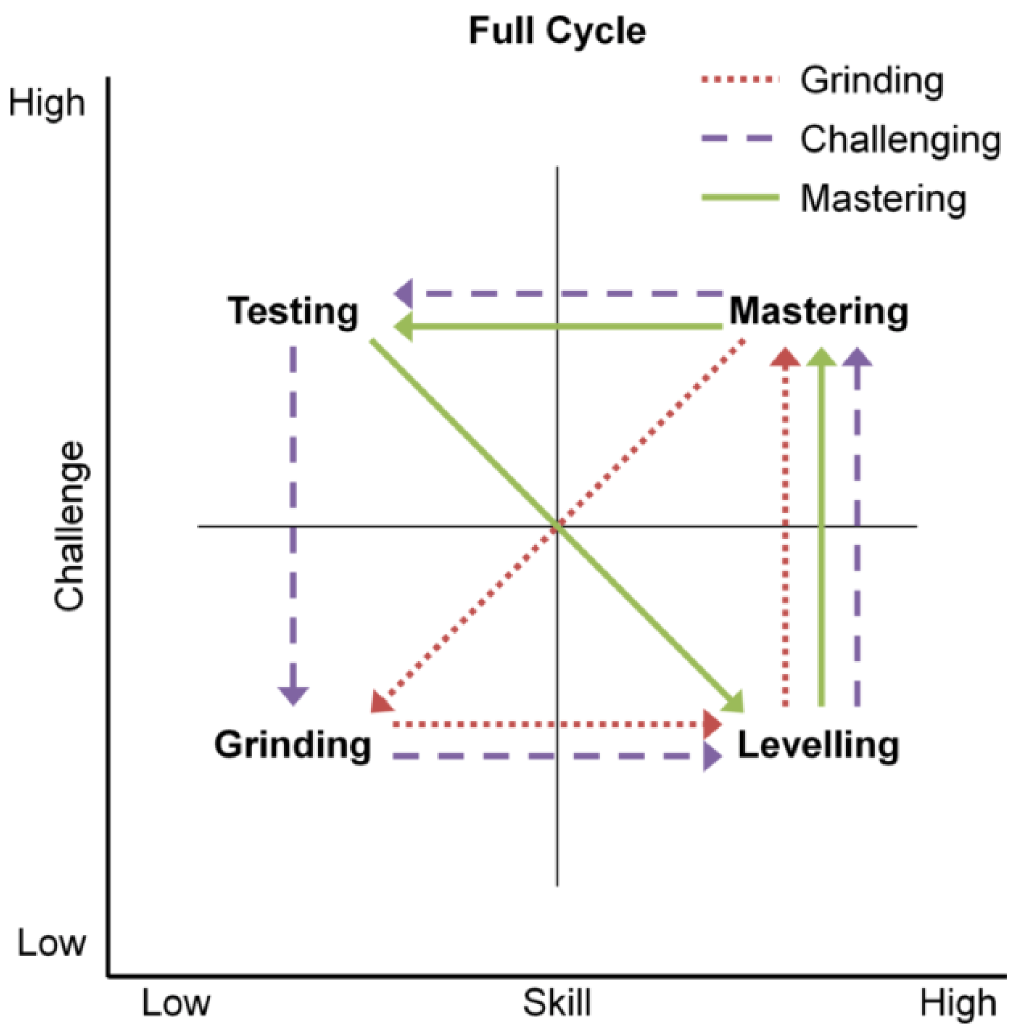


Figure 2.31.: Cycles, phases, and transitions. Retrieved from Marczewski [Mar15]

By repeating these cycles, flow is achieved and maintained [Mar15] (see Fig. 2.32).

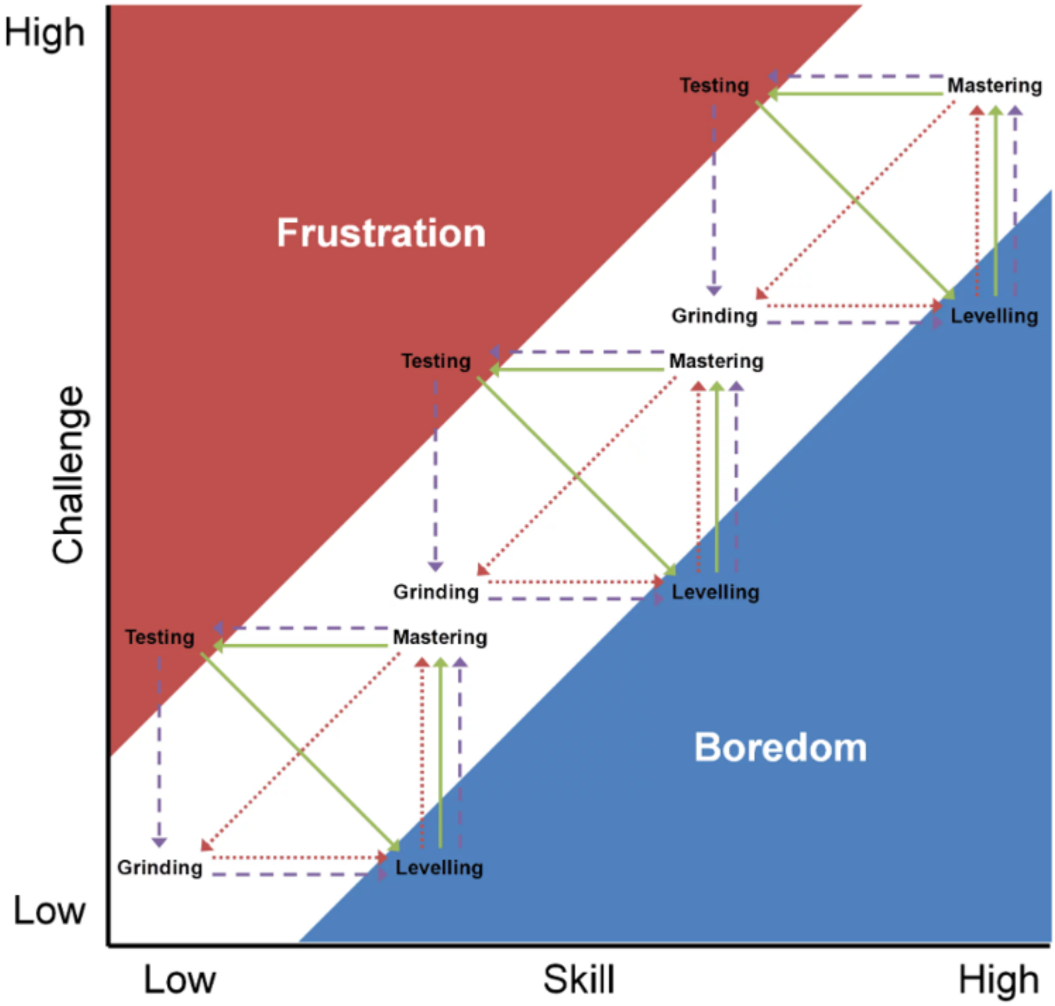


Figure 2.32.: Graphical visualization of grinding to mastery and mastery to flow. Retrieved from Marczewski [Mar15]

In summary, a game is well designed when it leads players into their flow zones and produces genuine feelings of joy and happiness [Che07]. Furthermore, to develop successful games and gamified applications, the design should also consider other factors such as immersion and presence.

Ryan [RRP06] developed the player experience of need satisfaction, extending self-determination theory and applying it to video games. When a player experiences a game, the three basic needs of self-determination theory are presented as an experience. In addition, presence is introduced as a new type of requirement to assess the sense of immersion in the game environment, and another variable, called intuitive controls, is included. The degree to which game controls are perceived to be intuitive can be characterized as an aspect of game quality rather than in-game experience. Intuitive controls increase motivation by increasing the player's competence and providing them with more freedom and control [RRP06].

2.6.5. Immersive Components of Video Games

There are many factors to consider when developing a holistic understanding of video games. This allows for an understanding of how their immersive components can be used in other areas, such as XR training.

Palmas, Reinelt, and Klinker [PRK21] analyzed video games from a comprehensive perspective and defined them as:

> *"[...] the result of a creative process which aims to entertain people by engaging them to interact with a game system via a computing device. The immediate response of each goal oriented interaction in a rule-bound gameplay system is displayed to the gamer. Typically, video games are characterized by adopting a graphical style and representation which follow a creator's vision, having playable and non-playable characters, taking place in a gameworld, utilizing a sound design (which may include music) and by being designed to create an enjoyable experience that can optionally be embedded into a story."* [PRK21]

To understand the immersive quality of video games, it is important to analyze a few individual immersive components.

In relation to video games, avatars are digital representations of players within the gaming environment. In most cases, they are controlled by the player and can be customized to some degree to suit their appearance and preferences. In addition, an avatar can be viewed as a tangible embodiment of the player's identity [Alj+19; Cas03; Duc+09; PN21].

Avatar representation in virtual environments allows increased player immersion and interactivity through the use of graphical representations ranging from stylized to complex photorealistic 3D models [PN21]. According to the proteus effect, users in virtual environments adjust their behavior based on their avatar's characteristics. The self-similarity with the avatar allows the user to feel a closeness to it. Ideally, the avatar should possess desirable traits, while undesirable traits can prevent this effect from occurring. In the context of self-perception theory [53], embodiment is particularly significant, as it is crucial in defining the threshold of perception based on the avatar's perspective [PG20].

In order for digital avatars to evoke an emotional response in the player, the uncanny valley effect [54] must not be underestimated. The closer the avatar appears to a photorealistic image, the higher the acceptance. However, there is a threshold beyond which photorealism is considered acceptable and and can no longer produce desirable acceptance effects [PN21] (see Fig. 2.33). At this point, the player develops high expectations of the realism of the representation, and even slight deviations from expectations lead to disappointment and rejection. For a person to regain acceptance, the avatar must remain as close to photorealism as possible [PN21; Rat19].

[53] According to Praetorius and Görlich [PG20], the self-perception theory suggests that people develop attitudes and identity traits based on their reflections on past experiences and behavior.

[54] Masahiro Mori, a Japanese robotics researcher, first described this effect in the 1970s.

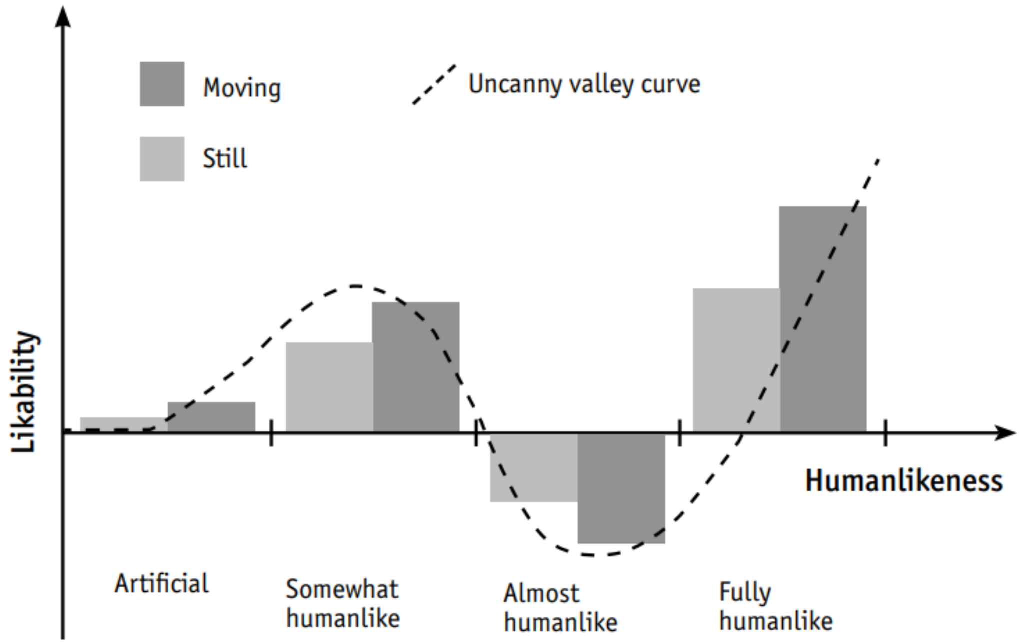


Figure 2.33.: Uncanny valley. Retrieved from Ratajczyk [Rat19]

An essential part of human culture is communication through stories. Many methods of storytelling share techniques to convey their messages and have been used across different media and industries. However, the fundamental aspect of video games that sets them apart from all other media is their interactivity [Dom17; PRK20].

Adding narrative to video games has been shown to increase their appeal to gamers by making them more interactive and immersive [Sch+06]. The player actively influences the course of the story through their decisions and actions within the game. Although interactive storytelling has made significant advances, most games still rely on a ready-made story [PRK20].

Dialogue is an important tool for storytelling in video games. By giving characters a voice, dialogue helps players dive into the story and feel more connected to the characters. Additionally, dialogue can help create a sense of place and atmosphere and can be used to create relationships between characters. When used effectively, dialogue can have a powerful impact on the player's gaming experience [SY17].

In summary, using avatars in video games is an effective way to give players a sense of immersion and connect with them on an emotional level. In addition, storytelling and dialogue play an important role in creating games that are engaging and meaningful to players. With this in mind, game developers can create compelling and successful video games by considering the role of avatars in relation to player retention.

3. Extended Reality Training

3.1. Defining Extended Reality

As the name suggests, XR encompasses immersive technologies connected to a variety of realities, such as VR, AR, and mixed reality (MR). Although XR technology has existed for some time, the X in the acronym stands for future technologies, which are also developed and classified under this umbrella term [PK20].

The conceptualization of XR found its foundation in Milgram and Kishino's [MK94] continuum of reality and virtuality [PK20]. Since then, this concept has been further developed in several publications over the years [Mil+95; MC+99]. In order to define the various immersive technologies, it is therefore necessary to first classify them accordingly within the reality-virtuality continuum.

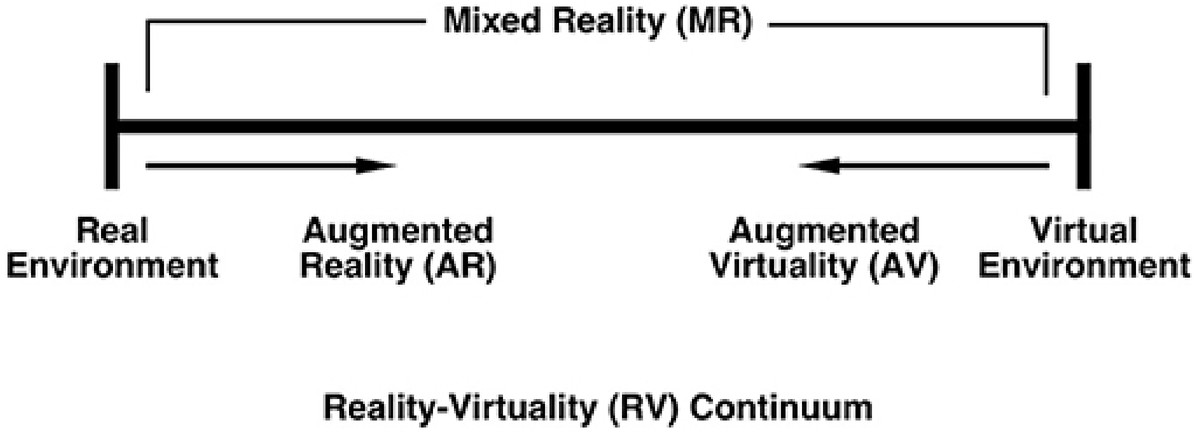


Figure 3.1.: Representation of the reality-virtuality continuum. Retrieved from Skarbez et al. [SSW21]. Representation based on Milgram et al. [MK94]

As shown in Figure (3.1), the real environment is on the left. This definition describes the actual human environment and consists only of objects and things that can be seen or looked at by humans without the additional assistance of any electronic display system. At the right end of the continuum, the virtual environment represents an counter-concept to the real environment, in which computer-generated objects make up the entirety of (virtual) reality. Therefore, augmented reality and augmented virtuality can be grouped between two opposite ends, which together span the full range of reality. Consequently, an MR environment falls somewhere between the extremes of the reality-virtuality continuum. In this context, a single display shows objects from both the real and virtual worlds [MK94].

The study by Skarbez, Smith, and Whitton [SSW21] goes a step further in examining the reality-virtuality continuum. According to the authors, Milgram and Kishino's original concept needs to be reconsidered given recent technological advances over the past 25 years. They claim that a perfect virtual environment is unattainable considering that the reality-virtuality continuum seems to be a discontinuous continuum. In addition, MR encompasses traditional VR experiences and is wider and more complex than ever before. By evolving the continuum, Skarbez, Smith, and Whitton take the role of the user into account, ultimately resulting in a 3D space that combines familiar parameters such as presence and immersion.

Palmas and Klinker [PK20] provide the following brief classifications of contemporary XR technologies:

- **Virtual Reality:** VR refers to a computer-generated environment that allows users to move in it, interact with it, and fully immerse themselves in it. Furthermore, integrating multiple types of hardware enables immersive experiences with full sensory simulation.
- **Augmented Reality:** AR refers to the overlaying of digital content with a physical environment. As the medium displays both digital and real content at the same time, there is no direct interaction with the environment. When users interact with the digital content using a computing device, they can also simultaneously experience the real world.
- **Mixed Reality:** In this context, MR refers to the combination of VR and AR. A layer of virtual content can be applied to and interact with the environment. By integrating the physical and digital worlds, AR facilitates the exchange of information and the interaction between these worlds.
- **Extended Reality:** As a concept, XR encompasses each of the three alternate realities above [1] as well as the possible future realities [2] that will expand the range of possible realities over time. Consequently, XR has almost limitless potential for the future.

Throughout this dissertation, the focus will be mainly on VR, which will be examined in greater detail.

3.2. Augmented Reality

The application of AR has garnered significant attention in the business and academic community in recent years due to its potential for adoption in a variety of disciplines and industries [ZS20]. Furthermore, AR devices are widely available today and typically fall into three main categories based on the placement of the display: head-mounted devices, handheld devices (see Fig. 3.2), and spatial devices [Von+17].

[1] Virtual reality, augmented reality and mixed reality.
[2] The X in XR symbolizes the inclusive nature of this concept.

AR has been described as a technology that makes it possible to integrate 3D objects into a 3D environment in real time [Azu97].

Azuma [Azu97] outlined the following characteristics of AR systems:

- In a real environment, it combines both real and virtual objects.
- Interactive and real-time operations are performed.
- Real and virtual objects are synchronized and aligned.

Due to rapid technological advances in this field, Azuma [Azu+01] decided to conduct companion research to his previous work [3].

Essentially, AR technology overlays computer-generated imagery over the real world environment to provide users with enhanced information and digital content.

As opposed to Azuma, who limits the concept only to the addition of virtual elements to reality, Dörner et al. [Dör+19] defined AR by mentioning the integration of all sensory perceptions associated with digital objects, and therefore consider it from the perspective of the user's perception.

[3] A survey of augmented reality.

Figure 3.2.: Example of an augmented reality application using a handheld device. Own source.

In addition to gaming and entertainment, AR has applications in various other areas, such as healthcare [FKC19; Zhu+14], marketing [BT10; Rau+22a; RFH19], manufacturing [BV19; Nee+12], maintenance [Hin+11; Pal+18], education [Bow+14; PWK19], and training [Lee12; SB19].

3.3. Virtual Reality

Defining VR is a long-standing challenge. According to the literature, the term is not defined uniformly or uncontroversially [Doe+22; Fuc17]. VR instead has several restrictive definitions that blur its purpose, functionality, applications, and techniques [Fuc17].

Fuchs [Fuc17] provides some definitions to help better understand VR from different angles. In summary, these are as follows:

- **Purposeful**: VR enables people to engage in sensorimotor and cognitive activities in a digital artificial world. The digital artificial world can be fictional, symbolic, or imitation, simulating aspects of the real world.

- **Functional**: As people can virtually change their place [4] and time, VR allows them to escape from the real world, interact in and with the virtual environment, and explore other realities.
- **Technical**: VR involves the creation of a simulated virtual world in which 3D entities interact with each other and users in real time, resulting in pseudo-natural immersion via sensorimotor channels.

The ambiguity of the definition of VR is also discussed by Doerner et al. [Doe+22] in its multiple facets, from its representation in science fiction and popular culture as a perfect simulation indistinguishable from real life, to its already established practical applications in many different industrial sectors. However, due to the rapid development of this technology, further applications are still being explored [Doe+22].

A definition of VR developed by Carolina Cruz-Neira in 1993 [5] includes several aspects relevant to this field, such as immersion, user-centeredness and interactivity:

> *"Virtual Reality refers to immersive, interactive, multi-sensory, viewer-centered, three-dimensional computer-generated environments and the combination of technologies required to build these environments."* [Doe+22]

Other approaches to defining VR focus on human-computer interfaces. The general belief is that a primary objective of VR is to establish human-computer interfaces that facilitate a seamless, more instinctive, and intuitive interaction with the three-dimensional setting [Doe+22].

In this context, Doerner [Doe+22] summarizes what distinguishes virtual reality from computer graphics (see Tab. 3.1).

3D Computer Graphics	Virtual Reality
Visual presentation only	Multimodal presentation (i.e., addressing several senses, e.g., visual, acoustic and haptic)
Presentation planning/rendering not necessarily in real-time	Real-time presentation planning and rendering
Viewer-independent image generation (exocentric perspective)	Viewer-dependent image generation (egocentric perspective)
Static scene or precomputed animation	Real-time interaction and simulation
2D interaction (mouse, keyboard)	3D interaction (body, hand and head movements and gestures) + speech input
Non-immersive presentation	Immersive presentation

Table 3.1.: Comparative properties of virtual reality and traditional computer graphics. Retrieved from Doerner [Doe+22]

[4] The world can be simulated, imaginary, or symbolic.
[5] SIGGRAPH conference 1993: course notes "Virtual Reality Overview".

In order to gain a deeper understanding of this topic and its current definitions and concepts, it is essential to delve into its history.

3.3.1. History

Our digital age is sometimes referred to as the digital revolution and is associated with VR. Although this technology is not a 21st century innovation, its beginnings can be traced to the turn of the 20th century.

In the early 1830s, the stereoscope was invented, opening a new era for research into binocular vision. Sir Charles Wheatstone was able to manipulate images and observe their depth as they were presented to each eye. He developed the first stereoscopic device, in which the image of each eye was split in opposite directions with two mirrors (see Fig. 3.3) allowing the use of large format images without overlapping [Wad02].

Wheatstone described his founding in the following statement:

> *"The projection of two obviously dissimilar pictures on the two retinae when a single object is viewed, while the optic axes converge, must therefore be regarded as a new fact in the theory of vision. It being thus established that the mind perceives an object of three dimensions by means of the two dissimilar pictures projected by it on the two retinae, the following question occurs: What would be the visual effect of simultaneously presenting to each eye, instead of the object itself, its projection on a plane surface as it appears to that eye?.... The stereoscope is represented by figs. 8. and 9.; the former being a front view, and the latter a plan of the instrument"* [Wad02]

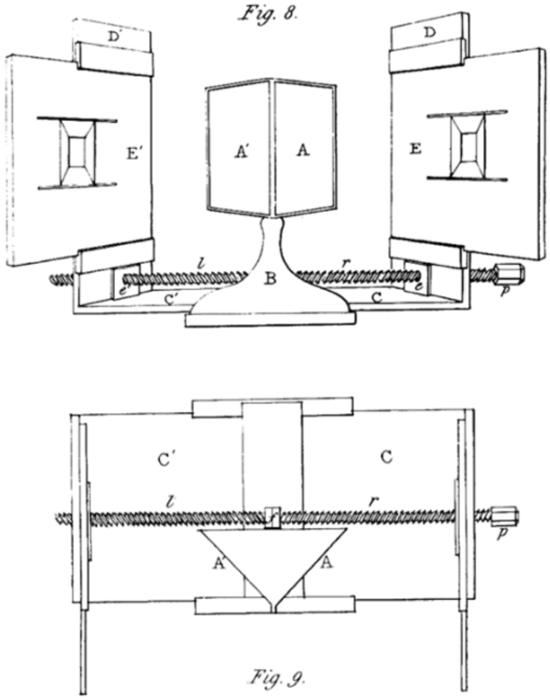


Figure 3.3.: Mirror stereoscope front and top view. Retrieved from Wade [Wad02]

This was the first head-mounted display capable of displaying three-dimensional video. However, the device did not offer tracking capabilities. Although this type of stereoscope displayed only still images, this was the beginning of a technological advance that eventually led to the development of the modern stereoscope and the birth of VR.

By 1957, Morton L. Heilig patented the first head-mounted display under the name "Stereoscopic-Television Apparatus for Individual Use" (see Fig. 3.4) and described it as follows [Hei57]:

> *"My invention is directed to improvements in stereo scopic-television apparatus for individual use. My invention generally speaking comprises the following elements: a hollow casing, a pair of optical units, a pair of television tube units, a pair of ear phones and a pair of air discharge nozzles, all coacting to cause the user to comfortably see the images, hear the sound effects and to be sensitive to the air discharge of said nozzles."* [Hei57]

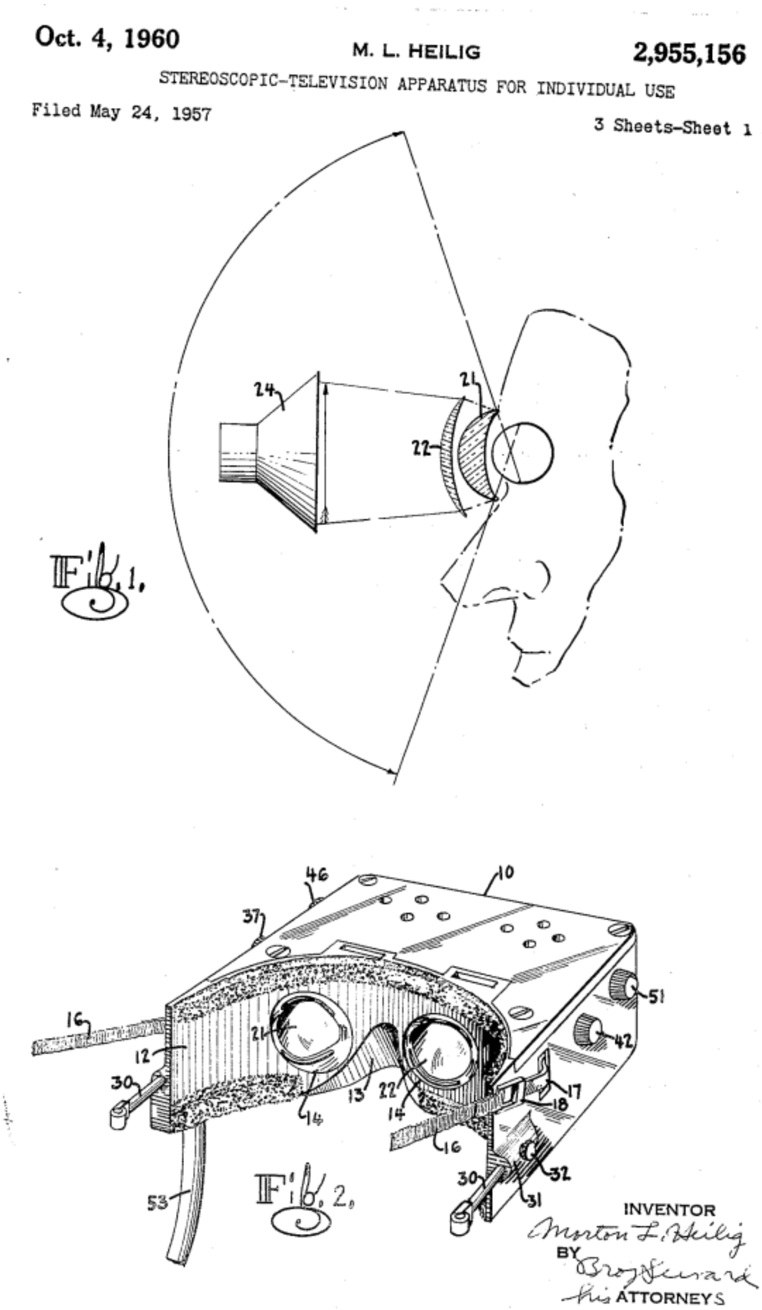


Figure 3.4.: Original patent sketch for the first head-mounted display. Retrieved from Google patents [Hei57]

This head-mounted display was capable of displaying three-dimensional video. However, the device did not offer tracking capabilities.

Morton Heilig developed the Sensorama and first demonstrated it in 1962. With its multi-sensory simulator, Sensorama gave users a whole new perspective on different environments and scenarios. Motorcycling through New York was a popular attraction and produced winds, noise, and smells similar to those of the city itself [Gig93]. Although the Sensorama was not interactive, it was a significant advance in the development of VR technology.

VR technology has evolved significantly since its inception in the 1960s. Known for his pioneering work in computer graphics, Ivan Sutherland [Sut65] described a visionary concept called "Ultimate Display". Essentially, this refers to a simulated reality so realistic that it is impossible to distinguish it from actual reality. An interactive graphic display, force feedback devices and sensory stimulation of smell and taste were all included in this concept[Sut65; Gig93].

Sutherland [Sut65] described the ultimate display as follows:

> *"The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked."* [Sut65]

In 1968, Sutherland invented a head-mounted display that allowed a graphic display to be updated to reflect the user's new perspective. Furthermore, this device tracked the movement of the user's head with a long mechanical arm, and the interactivity was still primitive. In this system, the viewer was provided with stereoscopic computer graphics images overlaid on real-world images using two displays viewable through half-silvered mirrors [Gig93; Sut68].

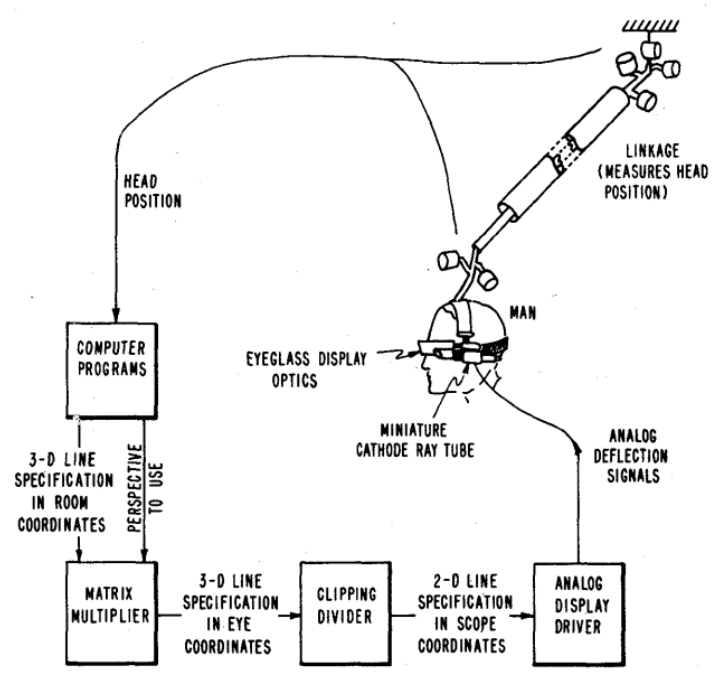


Figure 3.5.: An overview of the three-dimensional display system. Retrieved from Sutherland [Sut68]

Much of the development of VR technology in recent years was driven by the need for better military flight simulators. Tom Furness of the US Air Force Armstrong Medical Research Laboratories conducted significant research on VR [Gig93; SC18a]. In 1984, Mike McGreevy and Jim Humphries of the NASA Ames Research Center provided the basis for a modern VR setup to evaluate how useful a monochrome head-mounted display would be for future astronauts. Furthermore, research has been conducted to develop systems to track head and hand movements, wide-field monochrome stereo displays, speech recognition, 3D audio output, and tracked and instrumented gloves [Gig93].

Jaron Lanie coined the term VR in 1989 and conquered the mainstream in the following years [SC18a]. After its inception, VR experienced a period of popularity in the late 1980s and early 1990s. In addition, pop culture has played an important role in the spread of VR [Hei93]. However, VR commercialization attempts in the 1990s were typically unsuccessful [Boy09; Gar18; Mar+19; ZZ09] due to technical limitations [Bro99; Sto04]. As a result of this commercial setback, VR declined in popularity over the next decade. However, the research continued and advanced [SC18a].

The Oculus Kickstarter [Ocu12] campaign was a major VR event in 2012. This campaign attracted the attention and financial support of the general public, especially computer gamers, in addition to that of the usual research community [SC18a]. In retrospect, after a long history of unsuccessful technological innovation, this seems to have been the right impetus to spread the technique in modern times.

Today we have a wide range of head-mounted VR displays, all supporting head tracking, tracked controllers, stereo headphones, high-resolution displays, and low latencies. In 2019, Oculus introduced a standalone VR device called the Oculus Quest. Due to its technical characteristics and affordable price, it has been disruptive on the market [Por19; Tim19]. Oculus Quest was also recognized as one of the best inventions of 2019 [Tim19]. A year later, the company released its successor, Oculus Quest 2, which quickly became very popular and widely used. Additionally, more than one million Oculus Quest 2 [6] headsets were sold worldwide in the last fiscal quarter of 2020 (see Fig. 3.6) [Sup21].

[6] Meta (formerly Facebook) has announced in 2022 that it will be renaming its VR product line to Meta (formerly Oculus).

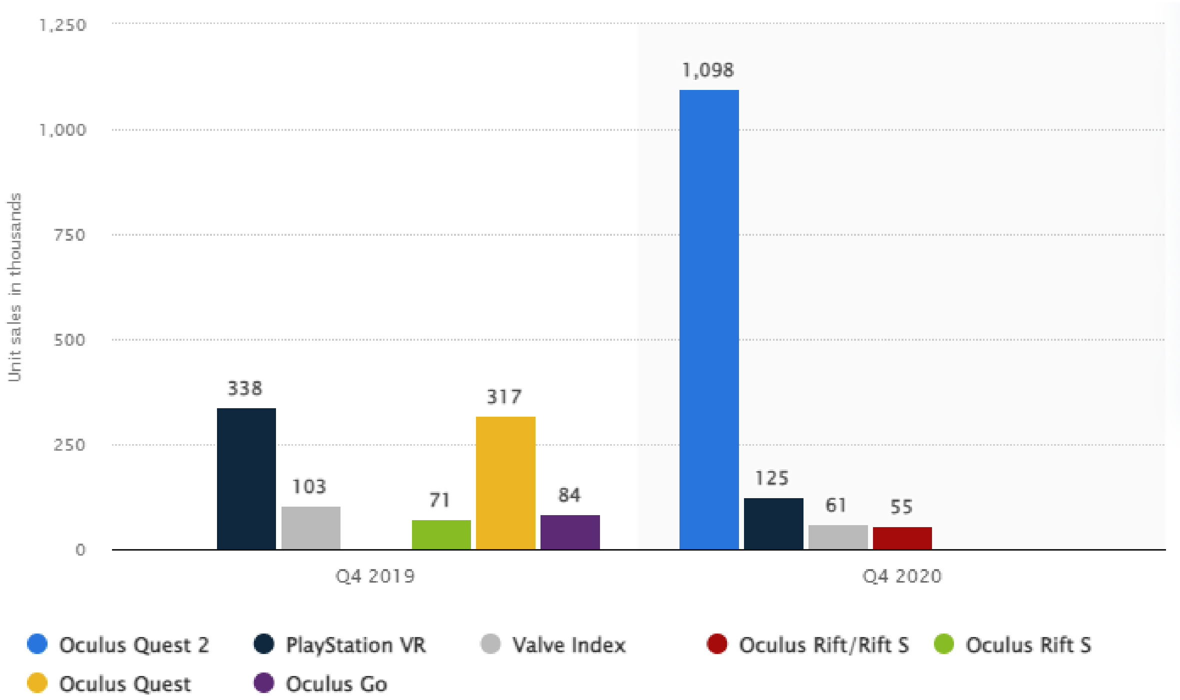


Figure 3.6.: Global unit sales of virtual reality headsets in the fourth quarter of 2019 and the fourth quarter of 2020, by device (in 1,000s). Retrieved from Statista [Sup21]

There seems to be a positive future for immersive technologies if they continue to evolve in positive direction. The global market for AR, VR, and MR is expected to reach $250 billion by 2028 [The22]. Immersive technologies, and VR in particular, are expected to thrive due to the growing popularity of the metaverse concept in recent years. Neither this concept nor its application are discussed in detail in this thesis. Instead, a general overview of it is given. According to Wang et al. [Wan+22], the concept of the metaverse can be summarized as follows:

> *"Metaverse is a self-sustaining, hyper spatiotemporal, and 3D immersive virtual shared space, created by the convergence of physically persistent virtual space and virtually enhanced physical reality. In other words, the metaverse is a synthesized world which is composed of user-controlled avatars, digital things, virtual environments, and other computer-generated elements, where humans (represented by avatars) can use their virtual identity through any smart device to communicate, collaborate, and socialize with each other. The construction of metaverse blends the ternary physical, human, and digital worlds."* [Wan+22]

Figure 3.7 illustrates the architecture of the metaverse.

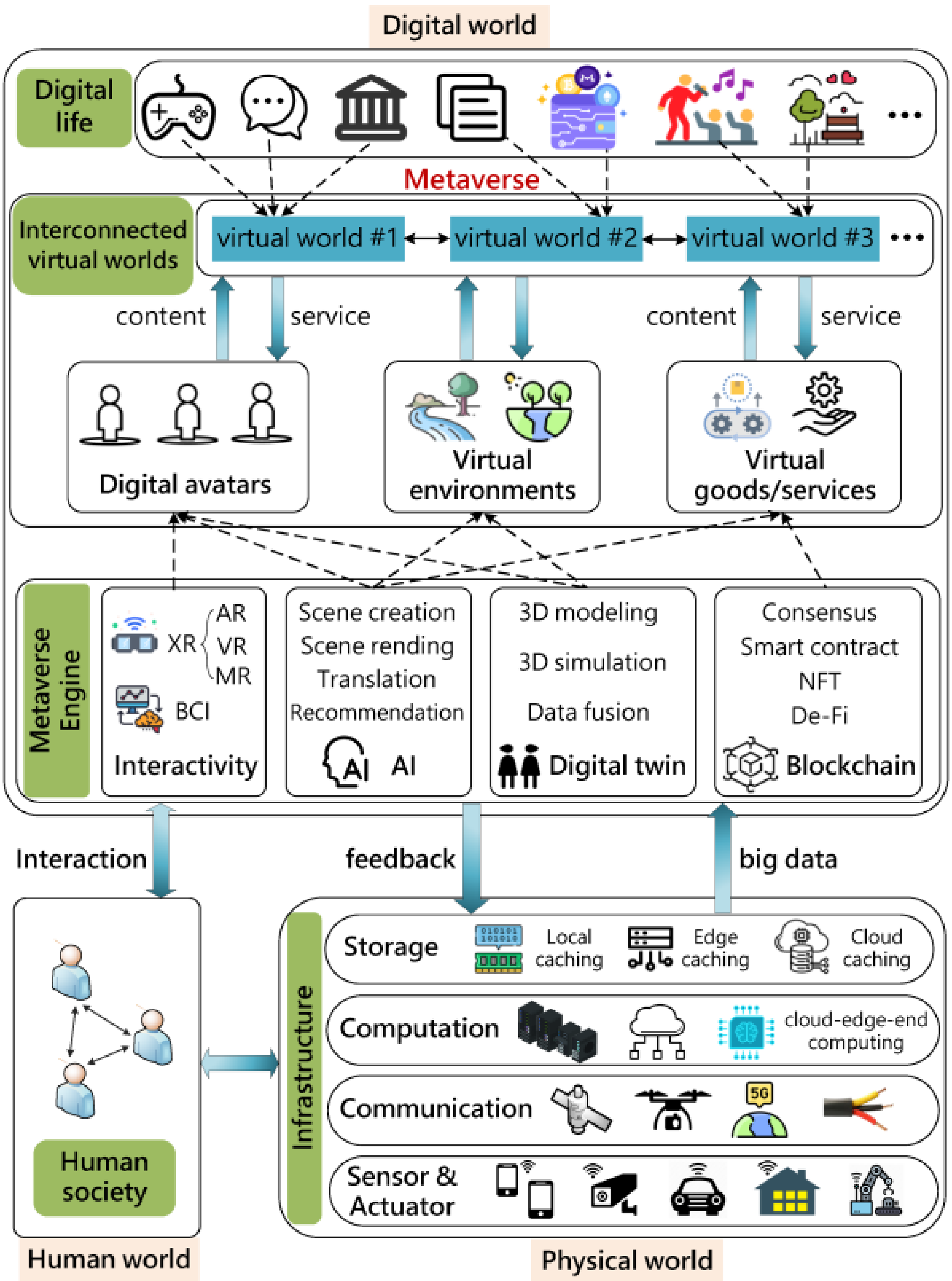


Figure 3.7.: The general architecture of the metaverse. Retrieved from Wang et al. [Wan+22]

3.3.2. Technical Specifications and Characteristics

In essence, VR simulates the experience of being in a different physical environment through interactive experiences. The physical world can be replaced with digital inputs, allowing the creation of a VR where visual, auditory, tactile, and olfactory inputs are replaced with digital data used to drive the provision of representations and perceptions to the brain [PS20]. VR can be experienced with the use of certain technical systems. A variety of platforms and systems can be used to experience VR, from simple mobile apps [7] to immersive setups in which images are projected onto three to six walls of the room [8] to complex computer-based applications [PS20].

These VR systems allow users to immerse themselves in a simulated environment. To this end, real-time graphics can be used to create a computer-generated environment, head-mounted displays can be used to view the environment, and interface devices and body tracking sensors can be used to track movement, and synchronize both physical and virtual environments [PS20; TST19].

Doerner et al. [Doe+22] defined a VR system as follows:

> *"We call a VR system a computer system consisting of suitable hardware and software to implement the concept of Virtual Reality. We call the content represented by the VR system a virtual world. The virtual world includes, for example, models of objects, their behavioral description for the simulation model, and their arrangement in space. If a virtual world is presented with a VR system, we speak of a virtual environment for one or more users."* [Doe+22]

To make interactive virtual environments [9] and digital objects, multiple creation processes are required using a variety of software programs. To achieve video game quality graphics with varying degrees of realism and interaction, it is essential to use game engines, 3D modeling and texturing programs, and motion capture tracking systems [PS20]. In addition, audio middleware can provide several benefits when creating virtual worlds and integrating 3D sounds into the game engine.

In this context, it is important to introduce some relevant concepts and terminologies to understand what leads to VR applications being perceived as an experience.

Immersion is an objective property of a VR system, which refers to how well that system supports natural sensorimotor contingencies for perception, which encompass responses to perceptual acts. VR systems can be classified according to the level of immersion provided. If a system supports full-body perception, it would provide a higher level of immersion than one that allows only the user to see the screen of a display [Sla18]. Consequently, adding additional hardware to a VR system that appeals to other human senses can further enhance

[7] Mobile virtual reality is based on the combination of a smartphone and a simple viewing device (e.g., a cardboard viewer).

[8] Typically, these systems are called CAVEs.

[9] E.g. virtual worlds.

the sense of immersion [PN21].

Sherman and Craig [SC18a] defined immersion as follows:

> *"Immersion sensation of being in an environment; can be a purely mental state or can be accomplished through physical means: physical immersion is a defining characteristic of virtual reality; mental immersion is probably the goal of most media creators."* [SC18a]

This definition states that immersion can be viewed as a dichotomy between mental and physical [10] immersion. In order to provide a sense of immersion in the virtual world, physical immersion is an important part of VR systems and experiences. An example of this would be a person physically entering a medium. Through the use of technology, it is possible to achieve physical immersion by providing synthetic stimuli from the senses of the body [11] in response to the individual's position and actions [SC18a]. The definition of mental immersion can be summarized as delving deeply into something by giving up disbelief and entering into it fully. Mental immersion is critical to the fulfillment of a VR experience and can act as a tool to facilitate communication. It also provides insight into the effectiveness of communication. A certain level of engagement indicates the success of virtual world communication. Depending on the application, its goals, and its requirements, a high level of mental immersion may not be feasible, desirable, or even necessary [SC18a].

An approach to cognitive studies of immersion and interaction in virtual environments is based on a subject's activity. Fuchs [Fuc17] proposed an anthropocentric user perspective to facilitate the understanding and design of virtual world applications (see Fig. 3.8). To achieve an optimal level of immersion for VR applications, designers should take a human-centric approach when designing VR applications. Designers absolutely need to consider a technocentric approach when creating immersive VR applications. This is because of the important role that the interface process and devices play. In order to understand the difficulties of designing VR and the possible errors in user interaction with artificial environments, it is necessary to consider the duality of VR.

[10] Sensory.

[11] It is important to note that this does not mean that all of the senses need to be stimulated in order to experience immersion.

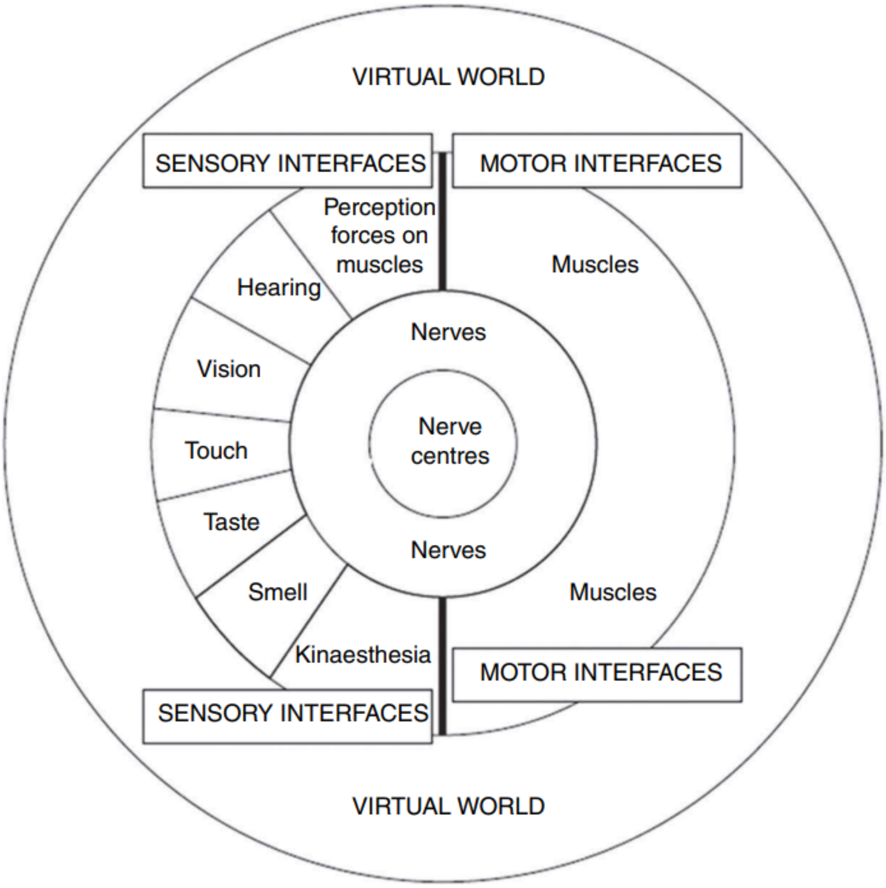


Figure 3.8.: The diagram illustrates how humans perceive the virtual world from an anthropocentric perspective. Retrieved from Fuchs [Fuc17]

Although immersion is consciously understood as virtual, VR applications have ecological validity because the brain automatically interprets them as real. Therefore, VR is also a useful tool for immersive training in a variety of fields [TST19].

For instance, experimental psychology has become increasingly interested in the use of virtual environments in recent years. This is due to the ability of these environments to present stimuli dynamically and in a controlled manner that affect different modalities simultaneously. Consequently, VR has proven to be a very valuable tool for studying the effects of various stimuli on human behavior [Gra20].

Presence broadly describes the sense of presence and mental immersion [SC18a]. Despite knowing that one is not present, the purpose of this state is to give the illusion of being present. Moreover, presence can be considered a perceptual illusion rather than a cognitive one [Sla18] meaning, that people's sense of presence is not determined by where their bodies are located but by the perception of being in a virtual environment [SS05]. In VR, emotional experiences are related to the concept of presence, and to evoke emotional reactions, users must be perceptually stimulated and receive feedback on their actions [Die+15].

Degrees of freedom in VR refer to the number of axes along which a user can move. Headsets with three degrees of freedom track rotational movement only, while headsets with six degrees of freedom track rotational and positional movement [SC18a] (see Fig. 3.9).

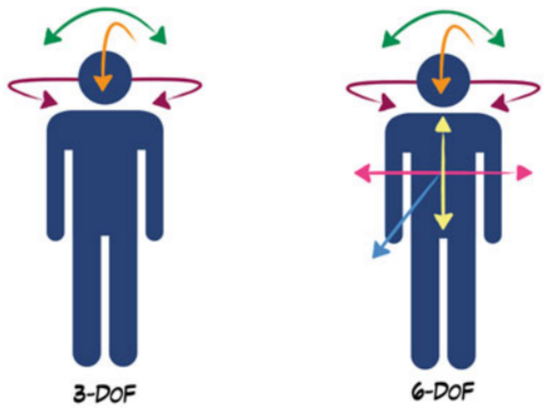


Figure 3.9.: A comparison of three- and six-degrees-of-freedom. Retrieved from Palmas and Niermann [PN21]

Avatars are used to represent users in virtual environments. Originally from Hindi, this word refers to the physical manifestation of a deity. Users can embody avatars in any visual form and take on any visual properties [SC18a]. Gonzalez et al. [Gon+20] show how important it is to animate the facial expressions [12] of avatars to create a stronger identification with them. Although avatars do not resemble the user, animating their facial expressions enhances self-identification with the avatar. Furthermore, Slater [Sla17] suggests that the use of avatars and their movement translations into virtual environments can be used to learn implicitly [Sla17].

Embodiment enables users to experience virtual body ownership [Sla17]. It offers users the ability to control an avatar in a first-person perspective, as if the avatar were their own bodies and the source of all their sensations [13]. Embodiment illusions are influenced by the user's perception of ownership of the avatar's body, also known as body ownership. In addition, users take control of avatars and own their appearance. Consequently, there is a direct relationship between embodiment illusions and the avatar's position in relation to the body. The avatar must be co-located with the user to experience an embodiment illusion [GP18].

Ethics and its implications for VR cannot be ignored. From the design phase through the use of VR applications, developers must address ethical considerations similar to those that apply to other data-sensitive technologies. According to Ramirez [Ram22], consumers and the public can be exposed to harmful consequences from the use of virtual and AR

[12] Facial animation.

[13] According to Gonzalez and Peck [GP18], even without full-body motion tracking, a co-located avatar with a head-tracked updated view can create the illusion of embodiment.

technologies. In addition, not every user or company has appropriate rooms suited for VR use. This increases the possibility and risk of injury. Another ethical issue is related to the possibility of creating user profiles [14] from augmented and virtual reality applications that can be used to track user movements and behavior [Gaf22; KS22; Mil+20].

The visual quality and use of sensory stimulation of VR applications and technologies are continually improving, leading to the possibility of so-called superrealism. At this point, VR becomes indistinguishable from physical reality [Sla+20]. While this could offer several benefits, including broadening our horizons and introducing new types of experience, it raises many ethical questions.

According to Doerner [Doe+22], in the field of research and when developing virtual and AR applications, five perspectives should be considered, including their complex interrelationships and possible implications (see Fig. 3.10). Researchers may intentionally violate these guidelines under certain circumstances, but this should be adequately reflected and documented [Doe+22].

[14] End User of the application can be customer but also employees within a company.

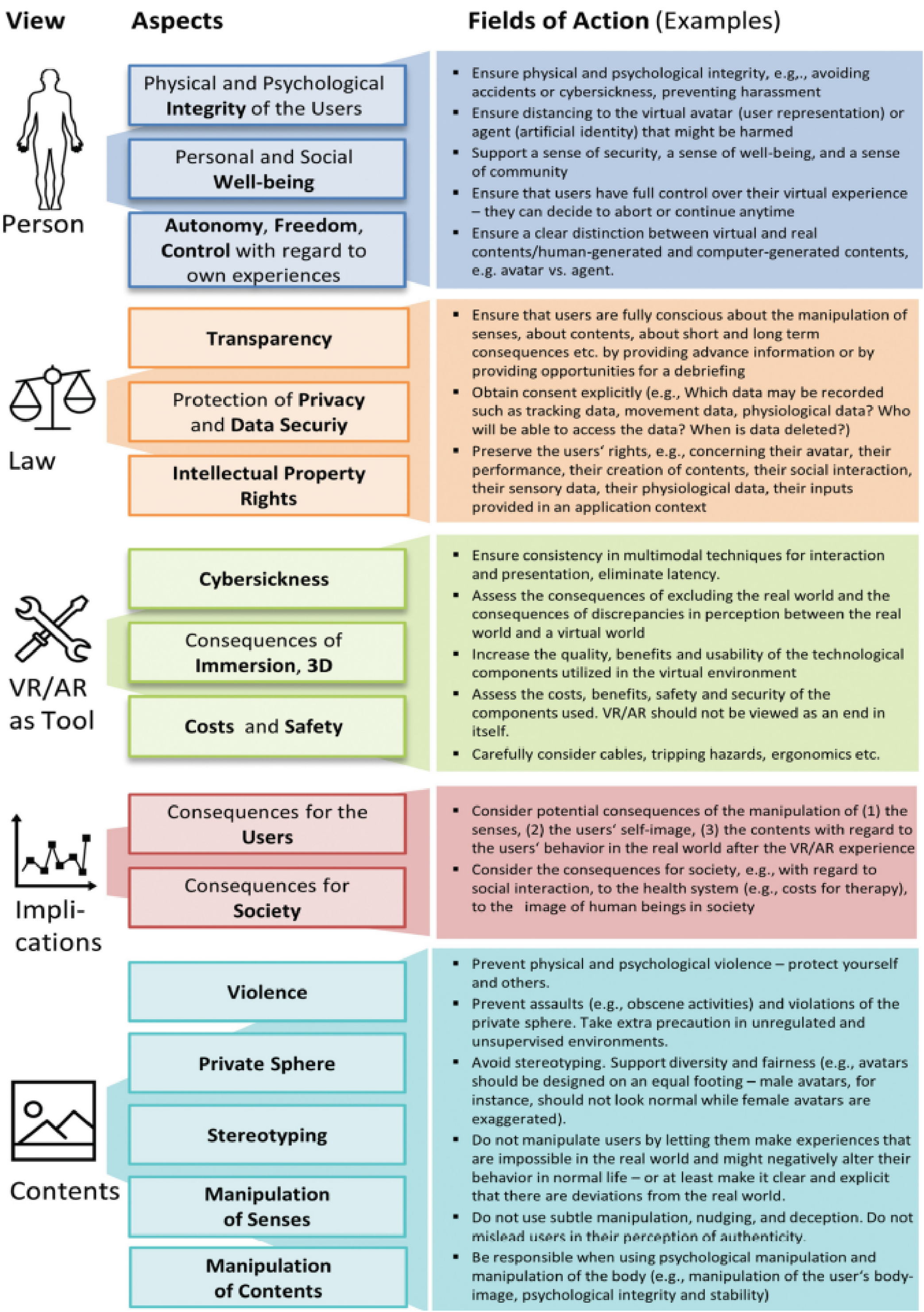


Figure 3.10.: In the five perspectives, virtual and augmented reality are analyzed with regard to their effects and fields of action. Retrieved from Doenner et al. [Doe+22]

3.3.3. Virtual Reality for Training

Virtual environments have been explored by researchers since the 1990s. Numerous frameworks have been developed to understand how VR and its environments can improve learning outcomes, suggesting that virtual environments have the power to transform education [Sou20]. Technological advances and the digitization of the educational environment have brought about a multitude of changes, and today's technology-driven learning environment poses new challenges for education. Skills that are indispensable in today's world must be acquired, and at the same time there is a risk that technology orientation will overtake the learning process [Dan20; Pal+22]. To understand the effective integration of technology into learning and educational concepts, it is crucial to identify the most effective approach to improving the individual's competence and to facilitate the transfer of learning to real-world situations.

Competence is characterized as a combination of knowledge, skills, and attitudes that allow an individual to act professionally in challenging circumstances and to comprehend the impacts of their decisions. Professional competencies are developed by engaging learners in situations that encourage traits such as creativity, autonomy, inquiry, and critical thinking in relation to common scenarios or real situations that may arise in future professional contexts [Fer+20]. Therefore, there is a growing interest in VR in the corporate sector.

Companies in various industries are increasingly using solutions based on AR or VR to increase their maturity, sustainability, and competitiveness. Various corporate goals can be achieved using this technology, for example, improving existing processes and organizational quality, optimizing time and costs, and developing new business models [KS22].

According to studies conducted in the twentieth century, people are likely to perceive messages differently depending on the medium through which they are delivered. As the medium becomes richer, the images of the space and situation become more realistic. Therefore, the more realistic the images of the space and situation are, the more likely they are to capture the audience's attention. This makes people more likely to feel like they are actually there. Therefore, the chosen training medium can greatly influence the training's effectiveness [Gra20].

According to Knoll and Stieglitz [KS22], the following main areas can be supported by AR and VR in a sector-neutral manner:

- Visualization of complex actual situation
- Modelling and simulation
- Collaboration
- Corporate communication: internal and external

In addition, there are several potential benefits associated with virtual learning environments with which people can interact or that they can use to learn. Southgate [Sou20] emphasizes the following benefits for learners:

- Development of spatial awareness
- Experience-based learning opportunities that would be either impractical or unattainable in reality
- Transfer of knowledge and skills learned in virtual environments to real-world situations
- New opportunities for fostering creativity in learning can be created through role-play and mentoring
- Provide learning spaces for practice, exploration, and experimentation [15]
- Improve learners' ability to engage in problem-based and exploratory learning

One of the most promising applications of VR is in the field of training. VR has already been used in a variety of sectors [JD21; PG22], including: healthcare [Man+03; ZA20], military [Pal+15], rehabilitation [Lam+06; ZA20], manufacturing [Abi+19; MSH04], maintenance [Gav+15], and education [Sou20].

A recent survey of industry professionals in the United States highlighted the focus on immersive technologies for manufacturing leading-edge applications [XRA20] (see Fig. 3.11).

[15] It is possible to integrate personalized user-generated content.

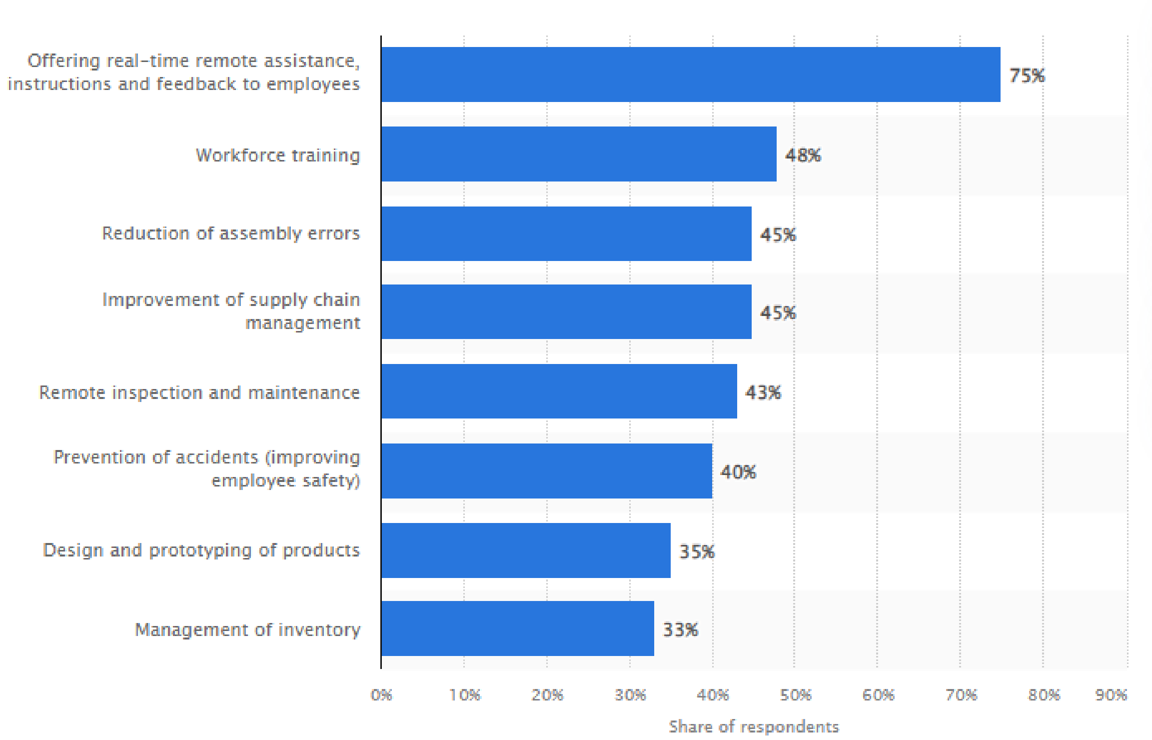


Figure 3.11.: Manufacturing applications of immersive technologies in 2020 according to industry experts in the United States. Retrieved from Statista [XRA20]

Although on-the-job training is one of the most common ways to acquire new skills because it is considered, in most cases, to be direct and natural, the effectiveness of this training method depends on the supervision of a skilled worker who explains how to perform the task accurately and efficiently. In addition, this type of training can be costly and time consuming. Clutter in the workplace can hamper productivity and take up space. With the help of VR simulations, some of the challenges of conventional training methods can be overcome, making realistic and efficient training possible [Gra20]. Moreover, one of the benefits associated with VR training is the ability to train people on specific procedures without any real-world consequences. This is a way to ensure that people have received appropriate training before engaging in the real process. Through this technology, users can also embody avatars and experience what it would be like to perform the process in the real world [Pal+21]. Additionally, the use of VR solutions seems to improve learning by making it more engaging, accessible, and fast [Dan20].

VR can be used to train people in a variety of scenarios and fields [JD21] that would otherwise be impossible to experience in the real world, allowing learners to gain experience in a simulated environment without the risks associated with real-world experiences. This includes sales or advisory talks, interpersonal conflict resolution, dealing with dangerous situations, and emergency training. In addition, VR can be used as a tool to provide information on complex service or repair cases [KS22].

Immersive VR training applications can be used to help trainees develop muscle memory and improve their ability to work efficiently. VR gives them the freedom of action and movement they need to perform real-world tasks in the workplace as they move from training to real job situations [Gra20].

According to Grabowski [Gra20], professional uses of VR at work include the following:

- Training workers to increase their efficiency and safety on the job [16]
- Supporting the evaluation and modification of work processes through the use of VR
- Interactive simulations within a virtual environment
- Interactive simulation of work processes to simplify and accelerate the process of designing and evaluating work environments
- Facilitating risk assessment at work; performing dangerous tasks while maintaining safe control of the teleoperator [17]
- Using motion capture systems and VR games to improve recovery from work accidents
- Simulating a real accident in a virtual environment to identify possible causes
- Improving the cognitive abilities of older people to retrain the unemployed and facilitate and improve their professional activation
- Using interactive simulations in a virtual environment to adapt workplaces to the needs of people with disabilities
- Developing and testing novel methods of interaction between humans and machines [18]

An immersive learning experience that uses VR could enable people to acquire the skills and knowledge needed to succeed in a specific area through an immersive learning experience. However, it is important to note that the use of VR alone may not be enough to ensure a successful training program.

Success in the field of training depends primarily on the training's effectiveness. In order to achieve successful results, effective teaching and training methods are necessary. Despite the importance of training, too little attention is paid to it when choosing a method [KS22].

[16] According to Grabowski [Gra20], in addition to procedural training, VR techniques are particularly useful in assessing decision making. Furthermore, gamification can be applied to training tools in virtual environments to increase their effectiveness and efficiency.

[17] In this case, the use of a head-mounted display, motion capturing systems, and gloves are required.

[18] In particular humans and robots.

3.4. Defining Extended Reality Training

Immersive interactive training systems have gained considerable momentum in recent years due to technological advances in mobile and XR systems. These technologies have the ability to enhance the learning experience and engage learners due to their interactive nature. They create immersive simulated environments that allow learners to practice and apply their skills in a safe and controlled environment [Pal+22]. Although the use of XR technologies is still in its infancy, they appear to be capable of transforming traditional methods of training and learning and hold the potential to significantly impact the approach to learning and training by offering various new training settings [Pal+22; PK20].

This section provides a depiction of the findings of the research "Defining Extended Reality Training: A Long-Term Definition for All Industries" by Palmas and Klinker [PK20]. The following sections are in part extracted and adapted from this publication. This research presents a set of common characterizations and concepts that provide clarity, ease of classification, and a definition of XR training that can be applied to all industries. Understanding these concepts is essential to reap the benefits of XR in corporate training.

3.4.1. Using Gamification for Immersive Learning

The integration of gamification into corporate training has gained attention due to its potential to improve the engagement and motivation of learners. Research supports the effectiveness of game elements in learning environments, and combining gamification with immersive technologies, such as XR, has shown promise in creating more immersive and engaging training methods. Furthermore, the possibility of developing multisensory approaches can improve the learning experience, support the learning transfer process, and lead to improved employee performance and productivity [PK20].

To assess mastery of these approaches, learners must demonstrate that they can apply the knowledge they have acquired to practical real-life scenarios. A high level of fidelity to the environment and interface can be beneficial in optimizing knowledge transfer in purpose-designed applications [PK20].

Combining computer generated content with extended technology results in the creation of immersive learning experiences that can meet the specific needs of individual learners. By combining these technologies with methodological approaches that take learners' needs into account to develop unique learning experiences, knowledge delivery can be enhanced more efficiently. This, in turn, improves the overall effectiveness of training interventions [PK20; PN21].

3.4.2. Training Domains and Continuum of XR Training Applications

There is a need to categorize training applications within a continuum that accounts for each type of training in the past, present, and future. This need results from the significant differences between the various training formats available on the market based on different hardware configurations and technologies [PK20]. Therefore, a novel concept called training domains was developed, which allows the categorization of training applications.

Palmas and Klinker [PK20] defined a training domain as follows:

> *"A training domain is defined as the most comprehensive classification of one specific typology of training application based on its unique technological characteristics."* [PK20]

All possible training applications can be assigned to one of seven individual domains developed by Palmas and Klinker [PK20] on their unique technical characteristics and selling points. A training domain represents the broadest classification of a particular type of training application. Thus, a training application can be accessed from multiple domains [19], but it can be classified as belonging to a specific domain only if it is specifically designed to take advantage of the use of the particular technology that defines it [PK20].

Palmas and Klinker [PK20] classified the training domains as follows:

- **Physicality** refers to the material and tangible aspects of the natural world and is synonymous with a truly unchanging physical environment that is often misconstrued as reality [20]. It encompasses all aspects of training that can be done in person without the use of technology. Although technology can be used to support a training session in this domain, a trainer is more likely to guide the trainee through the learning process in real life than through the use of technology.
- **Stationary Extensions of Physicality** [21] consider the desktop computer as the core technology. Any training designed for and conducted on a desktop computer falls into this domain. It is assumed that this core technology fails to leverage the technological advances offered by integrating VR or AR to enhance learning experiences.
- **Mobile Extensions of Physicality** include mobile technologies such as laptops, smartphones, and tablets. It is assumed that these technologies do not use the technological possibilities of VR or AR for learning purposes.
- **Augmented Reality** refers to technology that uses a combination of hardware and software components to allow users to experience digital content in a physical environment. In this process, mobile devices display both real-world and digital content simultaneously.
- **Mixed Reality** uses technology that merges the physical and digital worlds, blending VR and AR. It presents a superimposed layer of virtual content that interacts with real surroundings. The content is presented on a head-mounted display to facilitate

[19] E.g., a web browser on a VR device.

[20] Reality should be viewed as a concept that extends beyond the physical realm, as it encompasses abstract notions and cultural constructs, both of which transcend the physical realm.

[21] Due to the widespread use of their base technologies, the domains of stationary extensions and mobile extensions of physicality are particularly relevant to corporate training.

interaction between different realities either using controllers or hands-free using hand tracking.

- **Virtual Reality** implies a technology that allows users to fully immerse themselves in, interact with, and move within a computer-generated virtual environment. Using these types of application may require a head-mounted display is connected to a computer or a standalone VR device. The integration of different types of hardware can lead to the creation of immersive experiences that offer full computer-generated sensory stimulation.
- **Virtuality** refers to in-depth training that can be carried out in a sustained computer-generated or simulated virtual training environment that resembles and is comparable to real-world training. Technological advances could enable the creation of VR environments and training that can authentically replicate the sensory experiences of the physical world in the future. This type of immersive learning experience would be indistinguishable from training in the physicality domain. As a result of this type of training, it would be possible to bridge the gap between training in the domains of virtuality and physicality and provide an immersive and realistic learning experience.

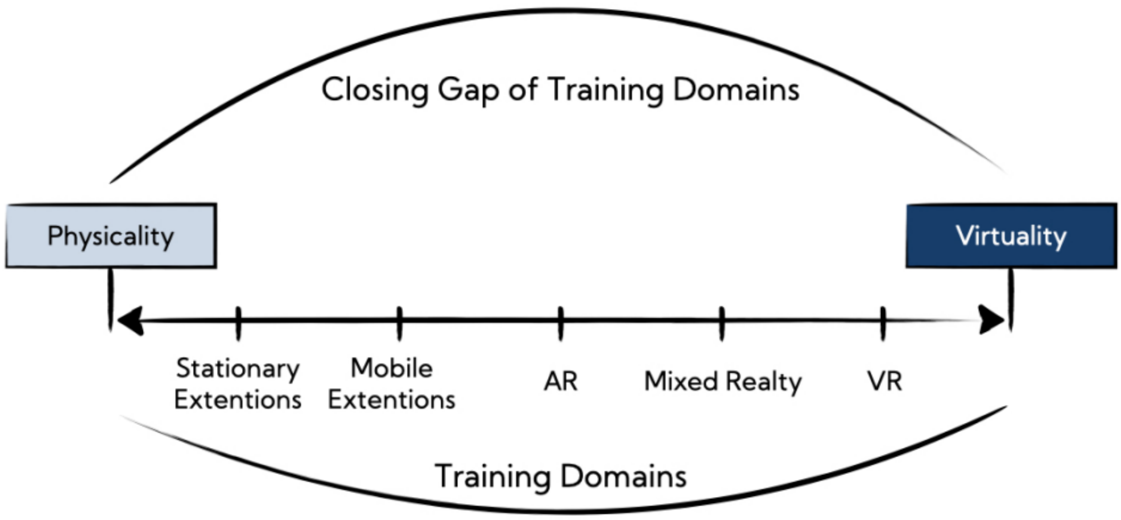


Figure 3.12.: The continuum of the XR training application. Retrieved from Palmas et al. [Pal+22]

To classify training applications, all domains can be represented on a continuum (see Fig. 3.12). The left end of the continuum represents the physical reality, while the right end represents a fully computer-generated virtual world. The virtual and real worlds are proportionally combined to produce the end product of a new training domain [PN21].

The creation of new domains under which new types of training can be classified according to their technological properties can be achieved whenever a new technology can be defined by its unique technological characteristics. Due to advances in technology and assumptions that future technologies will become available and be used for training applications at some point in the future, the position of previous XR training applications within the training domain may change [PK20].

3.4.3. The XR Training Definition

The purpose of this section is to bring together the discussions in the previous chapters on corporate training, gamification, and the technology behind XR training to define XR training.

Palmas and Klinker [PK20] defined XR training as follows:

> *"xR training is a purposely designed, immersive learning experience, which takes advantage of the appropriate technologies. These technologies engage and support employees when acquiring the knowledge and skills needed to drive the behaviors that impact specific business outcomes, which are aligned with organizational goals."* [PK20]

For a comprehensive understanding of this definition, Palmas and Klinker [PK20] explained the following terms, as follows:

- **Purposely designed** training can be viewed as an instructional methodology that refers to the use of specific techniques and strategies with the aims of motivating individuals to learn and of supporting their learning processes. These techniques include the use of gamification principles, elements, mechanics, and interactions in learning design. The purpose of purpose-designed instructional methodology is to enhance motivation and engagement in the learning process, ultimately leading to the achievement of a predetermined learning outcome. Overall, it aims to create an engaging, interactive, and motivating learning environment to facilitate the acquisition of new knowledge and skills.

- **Immersive training experience** refers to a learning experience in which an individual is immersed in the training application to a specified extent and degree, through either real or virtual immersion. The individual undergoes this training for a specified period of time to acquire new knowledge or skills. An immersive training experience is placed on the left, near the physicality domain, where the individual retains a presence in their physical surroundings and preserves cognizance of the tangible reality in the real world. Training experiences that merge the real world with the virtual world are located near the middle, resulting in a fully MR. It is possible to find immersive training experiences near the virtuality domain, to the right of the training area, allowing participants to fully immerse themselves in the virtual training world, forgetting about events taking place in their real physical environment.

3.4.4. Discussion

In recent years, technology has taken a huge leap forward, paving the way for developers to generate immersive VR applications that engage all five senses. As previously discussed in the description of the training domains, this level of immersion could offer huge advantages in training applications in the VR and virtuality domains, as users could explore and experience their surroundings more realistically without immediate dangers lurking around them. Being surrounded by a system with this kind of immersion allows users to fully immerse themselves in their learning process and ensure that they understand every aspect like never before.

However, it should be noted that the technology required to fully engage all five senses in VR is still in its infancy and will likely take some time to become widely available and affordable. Currently, the hardware needed for full sensory immersion in VR can be quite expensive and cumbersome to carry. Additionally, the technology may not be fully mature, which may cause discomfort to the user. But, as with any new technology, VR technology is expected to continue to improve and become more advanced over time. As developers continue to push the limits of what is possible with VR, it is likely that devices will become lighter, more comfortable, and affordable for the average consumer. In the future, it is possible that VR technology will become an integral part of everyday life, being used for everything from education and training to entertainment and socializing.

As we strive to bring the promising benefits of superrealism to VR, it is vital to weigh its moral implications and take steps to prevent potential harm. This could consist of formulating standards and regulations for applications, educating people about the risks associated with the technology, and using it as responsibly as possible.

An organization's learning journey can be enhanced through XR training designed to either provide a unique learning experience on a specific topic or establish a continuous learning process. Companies can leverage the technological capabilities at their disposal using this last type of approach. In this way, the company can create transmedia learning experiences.

The adoption of a transmedia learning strategy presents novel methods of accessing learning content across various training domains [PK20]. It can be very effective to combine technology and methodologies to build skills and deepen existing knowledge with the use of different training methods to support skill development and support learning in an effective and efficient way.

Developing a transmedia concept is a demanding and expensive process that requires careful planning and coordination, as well as significant resources. While the potential benefits of successful transmedia storytelling can be great, it is important that developers carefully consider the challenges and limitations of this approach before embarking on the development of a transmedia learning concept.

A successful company can also design different applications intended to provide training in hard and soft skills in competing organizations to gain an advantage over its competitors. Therefore, organizations must recognize the integral role that understanding and mastering hard and soft skills plays in achieving the desired performance outcomes. Therefore, it is imperative that companies analyze their organizational business goals and strategies to identify the skill gaps in their employees. By using this XR training, they can develop targeted training programs that motivate and empower their employees, as well as provide fundamental knowledge that increases productivity. Incorporating gamification and XR approaches into training contexts could enhance knowledge acquisition and retention, resulting in improved performance and productivity at work.

However, integrating XR training into a company's training program can be a complex and challenging process. Identifying best practices to implement these approaches requires further research to understand the mechanisms underlying their effectiveness.

3.4.5. Summary

Due to the profound impact that digital transformation has had on our lives, driven by constant technological advances, companies and employees are challenged to adapt to a lifestyle of lifelong learning that continuously engages learners with new training methods. XR has the potential to revolutionize corporate training by offering immersive and interactive learning experiences that are stimulating and impactful to employees. The purpose of this section was to provide a long-term definition of XR training that can be used across industries. In addition, a continuum of possible XR training applications was explained. Within this continuum, each potential training format can be categorized according to existing or emerging technologies.

4. Assembly Task in Virtual Reality

The use of VR simulations as a training and learning tool has become increasingly popular in recent years. As mentioned earlier, VR allows people to practice and develop new skills in a safe and controlled environment without supervision. This is particularly useful in situations where hands-on training can be difficult or dangerous, as well as in business situations where human supervision may not always be possible. Furthermore, supporting employee training with human oversight could negatively impact an organization at the expense of other business objectives [1]. In addition to looking at the learning curve for using VR technology, it is imperative to consider the role of gamification in training, as it can have a significant impact on effectiveness.

This chapter includes information on the software and hardware used in the publication "Comparison of a Gamified and Non-Gamified Virtual Reality Training Assembly Task" by Palmas et al. [Pal+19b], as well as a detailed description of the study performed to investigate the effects of gamification on knowledge transfer and task fulfillment in VR. The gamified and non-gamified VR training was developed by Labode [Lab18] during his master's thesis, and parts of the following sections have been extracted and adapted from the publication by Palmas et al. [Pal+19b].

4.1. Background

As a relatively new form of training, VR training has become widely used in research and offers several advantages. For example, if designed and implemented properly, it can reduce costs, improve training reproducibility, and provide a realistic and dynamic environment in which learners can practice and apply theoretical concepts. These properties make VR an effective tool to bridge the gap between theory and practice [Pal+21]. In addition to providing a safe and controlled environment for practicing skills that are too risky to try in the real world, VR can convey concepts without using language or other symbols. Furthermore, it has been shown that, in certain situations, skills acquired in a VR environment can be transferred to the real world [SB05].

Oren et al. [Ore+12] examined the effectiveness of training to assemble a 3D wooden burr puzzle in a VR environment using haptic devices and data gloves and in the real world using the physical puzzle itself. Although the group that received VR training was longer involved in the training than the group that received physical training, they assembled the physical test

[1] This cost can have a significant impact on a company. Opportunity cost can be viewed as a trade-off between two courses of action in which one must be sacrificed to gain the benefits of the other. In the context of economic efficiency, opportunity costs are often unseen and difficult to quantify.

puzzle significantly more quickly than the group that was instructed to complete the training in a physical environment. Accordingly, VR training can be more effective than traditional training methods in preparing individuals for real-world assembly tasks. In general, the study suggests that VR training may be an effective way to improve performance in real-world environments.

Constructivism theory is one of the most appropriate theories to explain the knowledge transfer capabilities of VR training applications. A learning environment similar to the actual environment in which the task is performed makes it easier for the learner to remember the experience [Ham05]. With the further development of VR technology in the areas of tracking, displays, and realistic graphics, it is becoming increasingly possible for VR learning environments to replicate the operational environment, which could potentially lead to better knowledge transfer.

Like any process, application, or task, gamification has the potential to benefit a variety of contexts, processes, and activities and can also be used in the context of learning. However, it can be difficult to quantify the efficiency of a gamified application. Moreover, several studies have examined the impact of VR in industrial and medical environments without considering the impact of gamified VR on these environments [Pal+19a].

Considering the potential of VR and gamification, it has been questioned whether integrating gamification elements into VR training could facilitate the delivery of learning content and simplify interactions within training scenarios compared to non-gamified VR training. To answer this question, a VR training application was developed that uses a similar approach to the VR training application by Adams et al. [AKH01] was developed. In order to create a neutral test base and test the adaptability of the concept in real situations, such as learning to perform tasks for a new job, a drum kit was chosen as the object of investigation. Drum sets are usually not assembled by people with no experience in drumming. After a VR training session, participants had to apply their acquired skills to assemble a drum set in the physical world.

4.2. Methods and Study Design

The methods and design of the presented study are described in the following subsections.

4.2.1. VR Hardware

In this study, the HTC Vive headset was used. It is a VR headset that includes a tethered headset with an OLED display and Fresnel lenses, two wireless hand controllers, and two lighthouses [2]. The headset has a refresh rate of 90 Hz and a resolution of 2160x1200 pixels [3]. It has a 110 degree field of view and uses the lighthouses to track the position of the headset and controllers using infrared light and laser beams. The controllers feature multiple input

[2] Infrared emitters.

[3] This corresponds to 1080x1200 pixels per eye.

methods, including buttons, a touchpad, and an analog trigger. The HTC Vive features low-latency tracking and allows room-scale movement in the tracking area.

4.2.2. Design of the Training Application

The training application used in the study was developed using the Unity3D game engine and features a 3D virtual environment that mimics the actual test room. The aim of the application was to train users in assembling a cymbal stand, which is a piece of drum hardware (see Fig. 4.1), which was chosen for its complexity and distinct assembly method that is not normally encountered in daily life. The cymbal stand consists of eleven components, including a tripod, two steel rods, a cymbal, four screws, a plastic washer, and two felt washers.

Figure 4.1.: Real cymbal stand vs virtual reality cymbal stand. Both are fully assembled.

To accurately simulate real-world conditions, the objects in the virtual environment were designed to interact with each other and the environment in physically realistic ways, including the application of simulated gravity and the ability to respond to user interactions. The VR system uses space-scale tracking that allows the user to physically move within a defined space to navigate the virtual environment. The tracked area has dimensions of approximately

2.5 meters by 2.5 meters, and any movement of the user, such as head or hand movement, is accurately reflected in the virtual world through the movement of the camera and controllers. This enables a seamless and immersive experience within the training application.

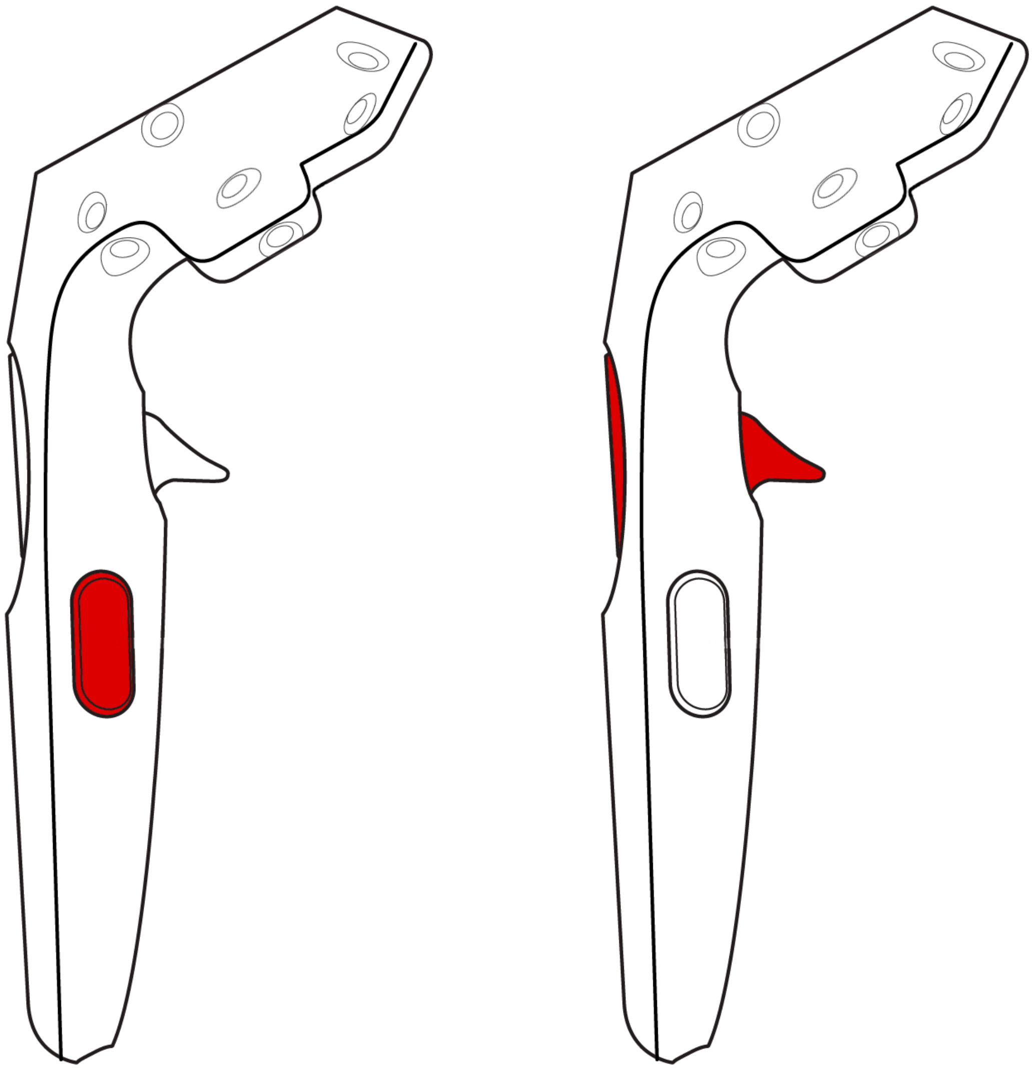


Figure 4.2.: Objects are picked up using the grip button (left), while the touch-pad and trigger (right) are used to interact with them. Retrieved from Palmas et al. [Pal+19b]

Users can interact with objects in the virtual environment of this application using controllers in two ways (see Fig. 4.2):

- They can pick up an object by approaching it with a controller and pressing and holding the grip button, which simulates the motion of grasping a cylindrical object in real life [4]. When an object is picked up, it follows the movement and rotation of the controller until it is released, at which point it is again affected by gravity. The objective of picking up an object is to bring it to its intended place on a virtual cymbal stand, where it snaps into place to become part of the overall structure.
- They can interact with an object by approaching it with a controller and pressing and holding the trigger and touchpad buttons, which simulate the pinching motion used to grasp and manipulate small objects such as screws. There are three possible interactions that can be performed with an object in this way: pulling, tightening, and turning.

These instructions are displayed in the virtual environment where the user can see them while participating in the training. The training application also includes instructional text displayed on the virtual workspace [5] that provides step-by-step instructions for assembling the virtual cymbal stand (see Fig. 4.3).

[4]Through this approach, a cymbal stand's steel beams or a similar cylindrical object will be picked up in the same manner as when picking up a real-life cymbal stand.
[5]Virtual desk.

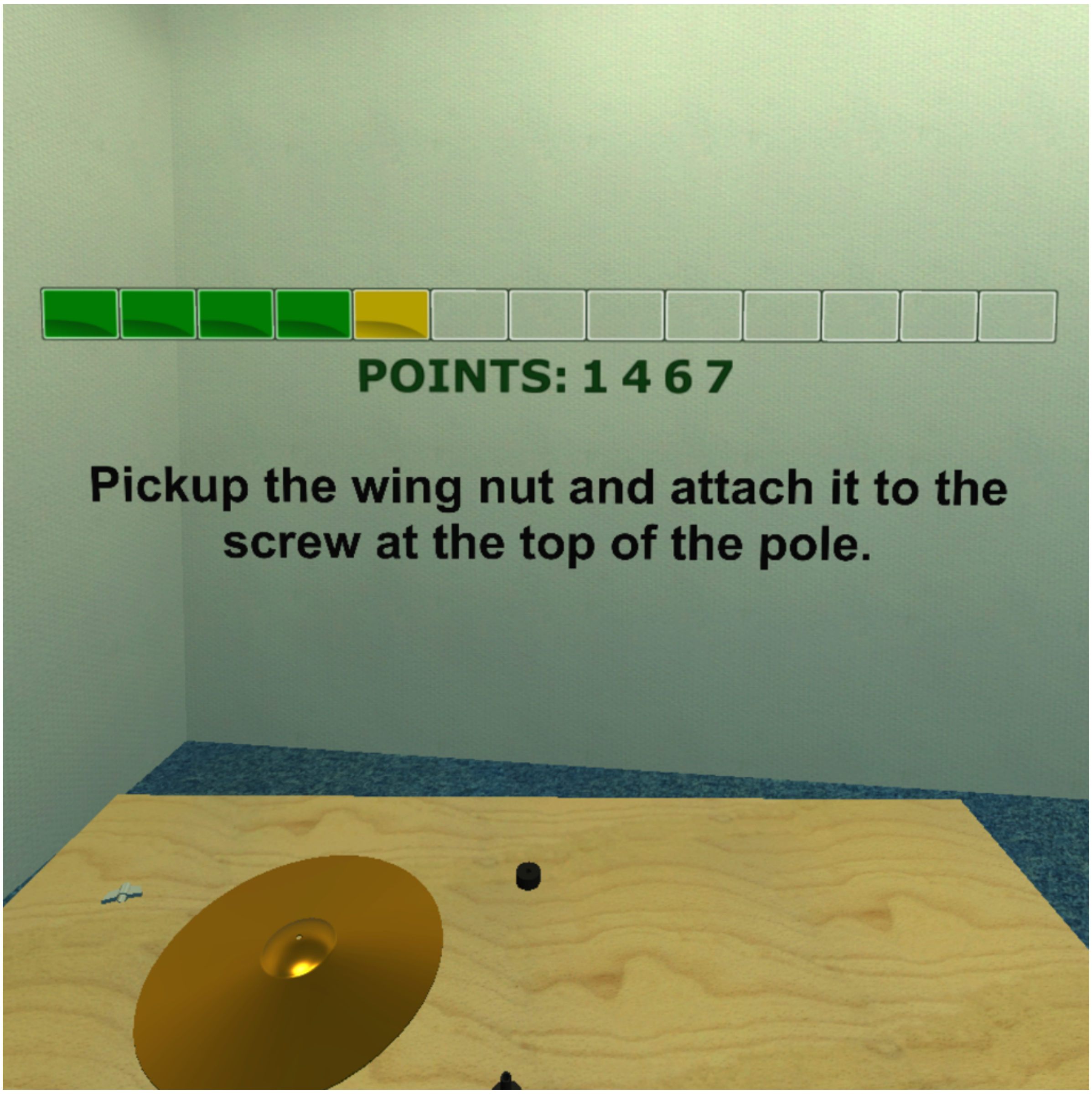


Figure 4.3.: An example of the training tutorial and its components. Retrieved from Palmas et al. [Pal+19b]

This guide text will be updated after each completed task. To aid in object manipulation and interaction, the program includes visual indicators, such as blinking objects and ghost images of the target position for each object. In addition, floating arrows provide guidance for certain interactions, such as specifying the rotation direction for the wing nuts or the correct orientation for moving hardware parts (see Fig. 4.4).

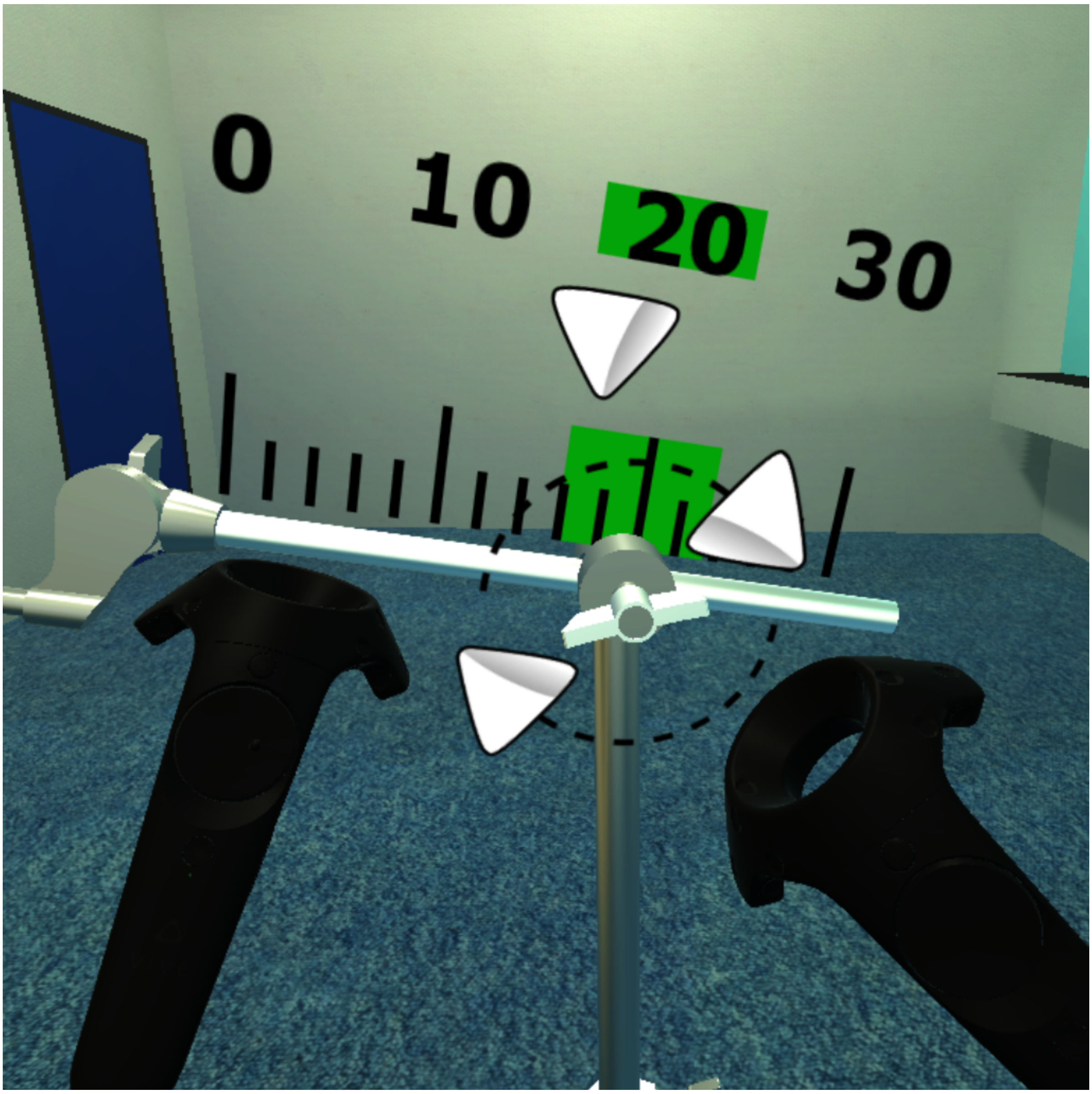


Figure 4.4.: A combination of arrows, scales, and flashing material is used to provide indications. Retrieved from Palmas et al. [Pal+19b]

The physical setup of the task is designed to reflect the virtual environment used for training. The physical workspace and objects [6] are arranged in the same configuration as in the virtual environment, and the physical objects are the actual counterparts of the virtual models used in the training (see Fig. 4.5).

[6]The desk and all items placed on it.

Figure 4.5.: Real-world setup compared with virtual training environment. Retrieved from Palmas et al. [Pal+19b]

Participants are expected to demonstrate their understanding of the actions and sequences learned during VR training (see Appendix A.1) by accurately reproducing those actions required for the assembly task in the real physical world. These actions include picking up and attaching objects to the virtual cymbal stand and securing them with wing nuts and holding objects in specific positions while securing them (see Fig. 4.6).

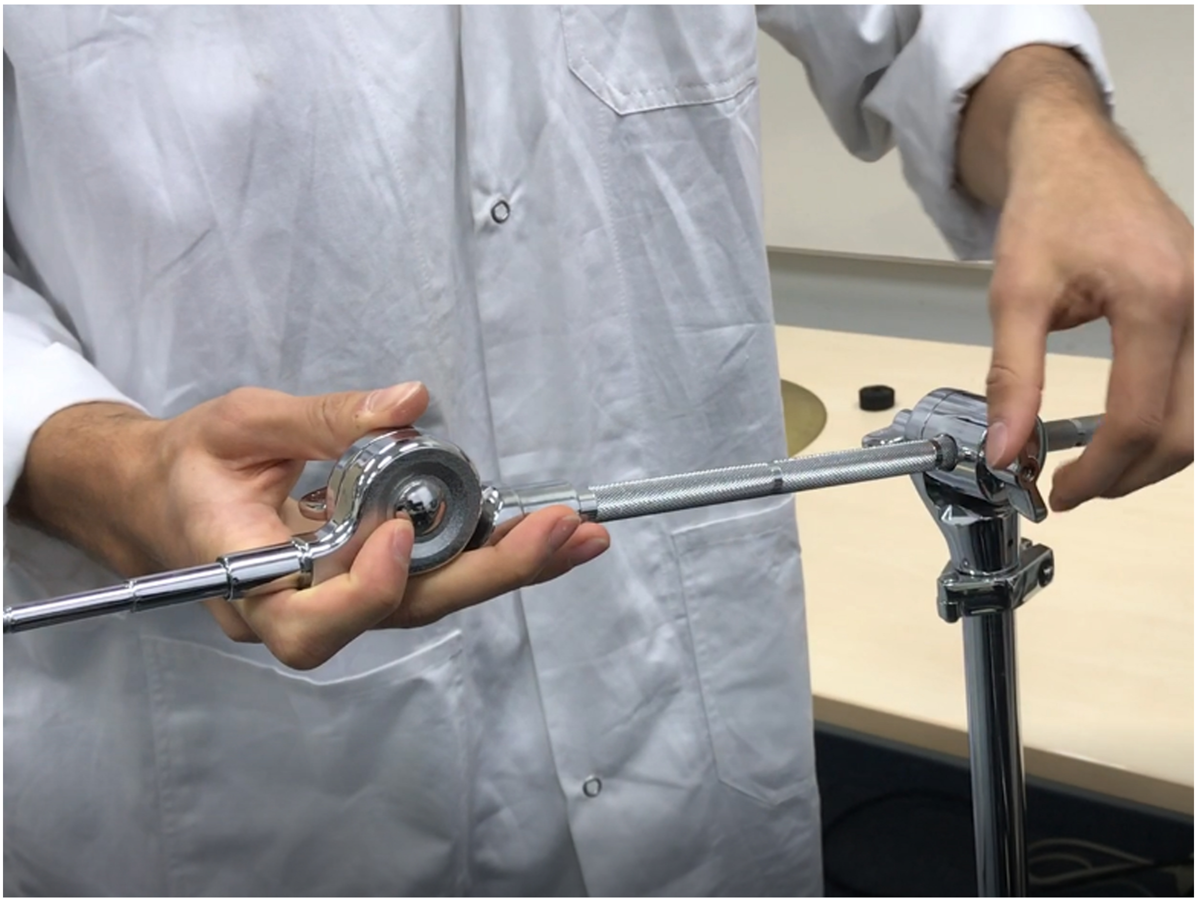


Figure 4.6.: Physical assembly task in the real-world setup.

The VR training application was developed in two versions, one serving as a control and the other as an experimental condition. The control condition includes all the features described in the previous explanations, but does not contain any gamification elements. In contrast, the experimental condition includes four specific gamification elements: progress bar [7] , points [8] , audio feedback, and visual feedback. These elements are intended to provide the user with motivation and a sense of progress.

A detailed explanation of these elements is provided by Palmas et al. [Pal+19b], as follows:

[7] To provide clear goals and feedback on progress.
[8] The feeling of reward is provided by them.

- **Progress bar** is contained in the training application within the user interface displayed above the tutorial text. This feature gives the user feedback on their progress while they view the instructions for the current or a new task. The progress bar consists of transparent blocks that represent individual steps in the tutorial, such as adding a component to the construction. As the user completes each step, the corresponding block is colored green to show the progress. The progress bar also includes a yellow block that shows the current step in the tutorial (see Fig. 4.4).

- **Points** are credited to the user after they complete each step of the tutorial. These points are displayed as large numeric sprites (see Fig. 4.7). The total number of points accumulated during the workout is displayed below the progress bar (see Fig. 4.4). The point system is designed to encourage the user to complete more difficult tasks, as these tasks are assigned higher point values. In addition, the system offers a performance-related bonus of up to 100% of the time required to complete the task. This aspect of the point system is intended to challenge users who may find the basic tutorial tasks too easy and not challenging enough.

- **Audio feedback** is provided during the training in the form of a drum fill that the user hears upon successful completion of a tutorial step. This serves to strengthen the sense of achievement and motivation, as well as provide information about individual progress.

- **Visual feedback** is provided upon completion of a virtual training application in the form of a celebratory particle effect. This effect simulates confetti falling on the user. This confetti rain effect is intended to provide a sense of achievement for the participant who has successfully completed all tasks and reached the end of the training program, and it serves as a visual indicator of the participant's progress and success (see Fig. 4.7).

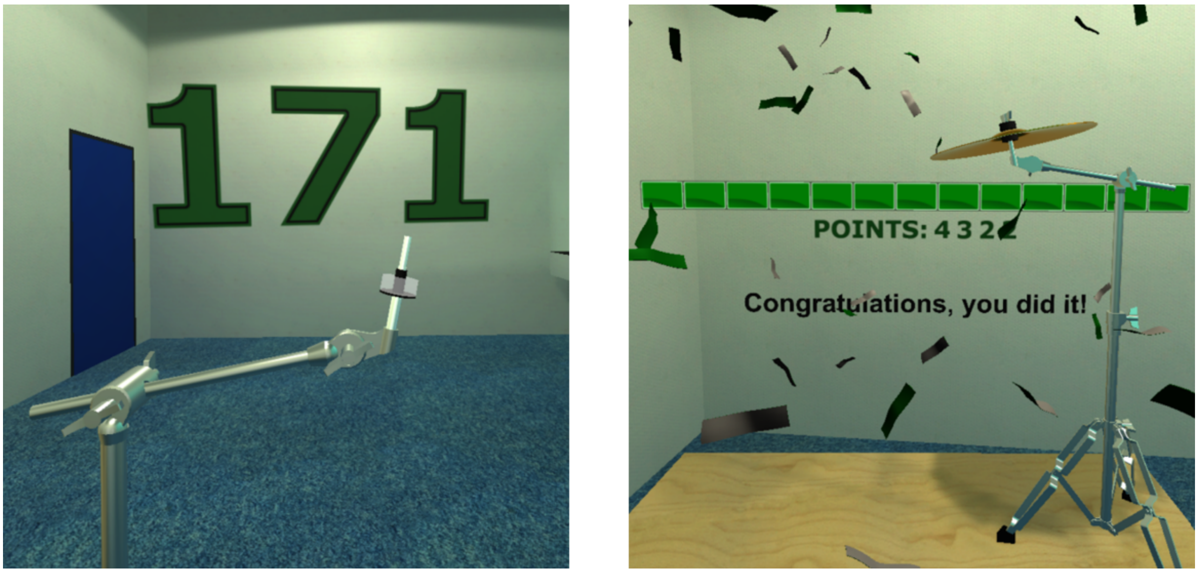


Figure 4.7.: Points displayed over the cymbal stand (left), confetti rain after completion of the assembly task (right).

4.2.3. Research Questions and Sample

The main hypothesis is that the use of gamification can improve the effectiveness of VR training in terms of knowledge transfer. To test this, specific subhypotheses were formulated:

- **H1** *The experimental group will exhibit a different distribution of error counts than the control group.* [9]

- **H2** *The experimental group will exhibit a different distribution of error criticalness than the control group.* [10]

In this study, 50 participants were randomly assigned to test the two sub-hypotheses (H1 and H2) with a gender distribution of 8 females and 42 males and a wide age range of 20 to 62 years. The age distribution of the 50 participants is shown in the Fig. 4.8. None of the participants had previous experience assembling a drum set and were unaware that two different test groups were used to avoid possible bias or competition between the groups. The experiment was conducted in a controlled environment to ensure that no external factors individually influenced the results, with all participants treated equally and given the same instructions. No participant dropped out of the study, and all completed the testing process.

[9] This hypothesis was proposed to test whether the number of errors has decreased overall for users of the gamified version.

[10] The purpose of this hypothesis is to determine whether users of the gamified version experienced a decrease in error criticalness in general.

In general, the study was designed to minimize potential sources of confusion and ensure the validity of the results.

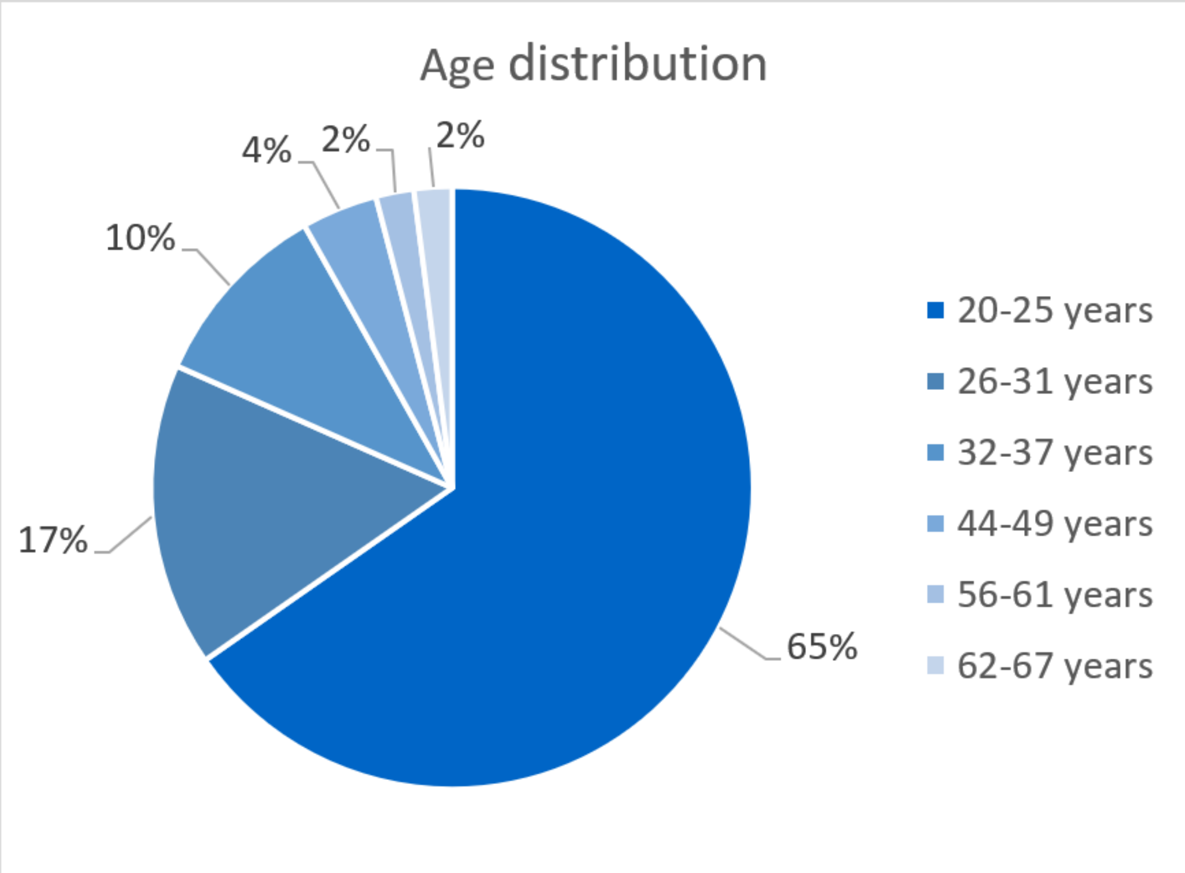


Figure 4.8.: The distribution of the 50 participants by age. Retrieved from Palmas et al. [Pal+19b]

So far, while the results indicated a trend towards a more effective gamified version, the initial analysis using the Chi^2 independence test did not show statistically significant differences between the two versions.

However, a subset of participants who were new to VR technology was examined, and a stronger trend was observed in favor of the gamified version. To further investigate this result, additional tests were run with another 7 VR novices using the gamified application and 7 using the non-gamified version. This expanded the subgroup to a total of 14 participants in both gamified and non-gamified conditions [11], resulting in a 1:1 ratio. Based on the initial results, two additional subhypotheses were formulated to further explore the potential benefits of gamification in VR training for VR novices and evaluate the data from the new sample:

[11] A total of 57 participants participated in the study.

- **H3** *VR inexperienced users of the experimental group will exhibit a different distribution of error counts than the respective part of the control group.* [12]
- **H4** *VR inexperienced users of the experimental group will exhibit a different distribution of error criticalness than the respective part of the control group* [13]

The data presented in the following discussion are based on a combined sample of 57 participants, including a subset of 28 people classified as VR novices.

4.2.4. Metrics

In this study, various performance metrics were used to assess the effectiveness of the training application on real assembly tasks. These metrics included both objective and subjective measurements, such as the time spent on the task and the number and severity of errors made during the assembly process [14]. Objectively, the time spent using the training application and completing the assembly task was recorded to determine the impact of the training on task efficiency. In addition, the number and type of errors that occurred during the assembly process were documented, as these can provide information on the quality of task execution and the number of steps required to correct the errors [15]. These serve as a measure of the relative importance of avoiding each error and allows the evaluation of hypothetical error scenarios [16].

Overall, the use of multiple performance metrics in this study allows for a comprehensive assessment of the effectiveness of the training application in real-world assembly tasks. These findings may have important implications for the design and implementation of future training programs in similar contexts. Table 4.1 shows the error descriptions and criticality values corresponding to the errors.

[12] This hypothesis examines whether users of the gamified version who had no experience with VR devices prior to this study will experience a reduction in error counts.

[13] This hypothesis aims to investigate whether the error criticalness decreases among users of the gamified version who have no previous experience of using VR devices.

[14] There are several common mistakes that people make when adjusting individual components. For example, forgetting to properly secure screws or attaching parts in the wrong order. Another example of a setup error is the failure to extend a part to the correct distance from the stand as specified by the participant during the training session. This error can occur if the person does not comply with the prescribed extension range.

[15] Each potential error scenario is assigned a criticality value, which is determined by the number of steps required to correct the error. This value reflects the impact of the error on the overall process, with higher values indicating more severe consequences.

[16] By analyzing the criticality of various error scenarios, it is possible to prioritize efforts to prevent or mitigate these errors in order to optimize the efficiency and effectiveness of the process.

Metric	Format	Description	Crit.
VR time	seconds	The time it took the user to complete the VR training	-
RL time	seconds	The time it took the user to complete the real-world task	-
Set pole	boolean	Whether the user failed to accurately adjust the setting of the vertical pole	3
Set rod	boolean	Whether the user failed to accurately adjust the setting of the horizontal rod	3
Acc turn	boolean	Whether the user failed to accurately adjusted the angle of the cymbal rod	3
Error 4	boolean	Whether the user inserted the horizontal rod pointing upside down	3
Error 6	boolean	Whether the user forgot to fix the horizontal rod in place	1
Error 7	boolean	Whether the user forgot to fix the cymbal rod in place	1
Error 10	boolean	Whether the user inserted the cymbal upside down	8
Error 15	boolean	Whether the user attached the last five pieces in an incorrect order	12
Error 16	boolean	Whether the user adjusted the angular setting of the horizontal rod	3

Table 4.1.: An overview of all metrics collected during the experiment. *Crit.* refers to *Criticalness*. Retrieved from Palmas et al. [Pal+19b]

4.3. Results

During this study, VR training and a practical real-world test were carried out. The collected data were anonymized and statistical significance was analyzed using the Chi^2 test for independence. The confidence level for these analyses was set at 95%, which corresponds to an α of 0.05.

Throughout this section, the null hypothesis H_0 is as follows:

Gamification has no influence on the results of the experimental group compared to the results of the control group.

The Chi^2 test was chosen to analyze the collected data due to its ability to handle non-normally distributed data. The data analyzed included the duration of the tests, the number of errors made, and the criticalness of those errors.

Group	VR Time in sec	RL Time in sec
Experimental Group	max 512 min 113 avg 303.38	max 249 min 63 avg 116.34
Control Group	max 580 min 201 avg 345.68	max 226 min 62 avg 109.52

Table 4.2.: Comparison of the time results obtained by the two groups tested in the virtual training and in the real world test. Retrieved from Palmas et al. [Pal+19b]

The results of the times recorded during the VR training and the practical test (in Table 4.2) show that the participants in the experimental group who used the gamified training application spent an average of 42.30 seconds less in VR training than the control group. This equals a 12.2% reduction in training time. Furthermore, the minimum and maximum training times for the experimental group were 88 seconds and 68 seconds shorter, respectively, compared to the control group, representing a reduction in training time of 43.8% and 11.7%, respectively. These results suggest that the gamified training application was effective in helping participants complete the training faster.

The results of the real-world test show a more even distribution compared to VR training, with the average completion time of both teams only 6.82 seconds apart (5.8%). The minimum and maximum times to complete the real-world task also show relatively small differences, with a difference of only 1 second in the minimum times (1.6%) and a difference of 23 seconds in the maximum times (9.2%). It is noticeable that the timing values of the control group are lower in the real world task, but overall these differences are relatively small.

In Table 4.3, the number of errors made during the real task is distributed among the experimental and control groups in proportion to the number of participants. The experimental group has 32 participants, and the control group has 25.

Group/Number of Errors	0	1	2	3
Experimental Group	7	10	12	3
Control Group	4	2	11	8

Table 4.3.: The number of errors made by the experimental and control groups during the real-world task. Retrieved from Palmas et al. [Pal+19b]

The results of the study showed that the experimental group using the gamified training application had a different error distribution compared to the control group. A notable finding was that the average number of errors per participant in the experimental group was 1.34, which represents a 30.2% reduction from the control group mean of 1.92. As illustrated in Figure 4.9, these results suggest that the use of the gamified training application was effective in reducing the number of errors made by the participants. However, no supporting evidence was found for the subhypothesis H1. These results suggest that the gamified training application had a positive impact on performance and reduced errors on certain tasks among participants in the experimental group.

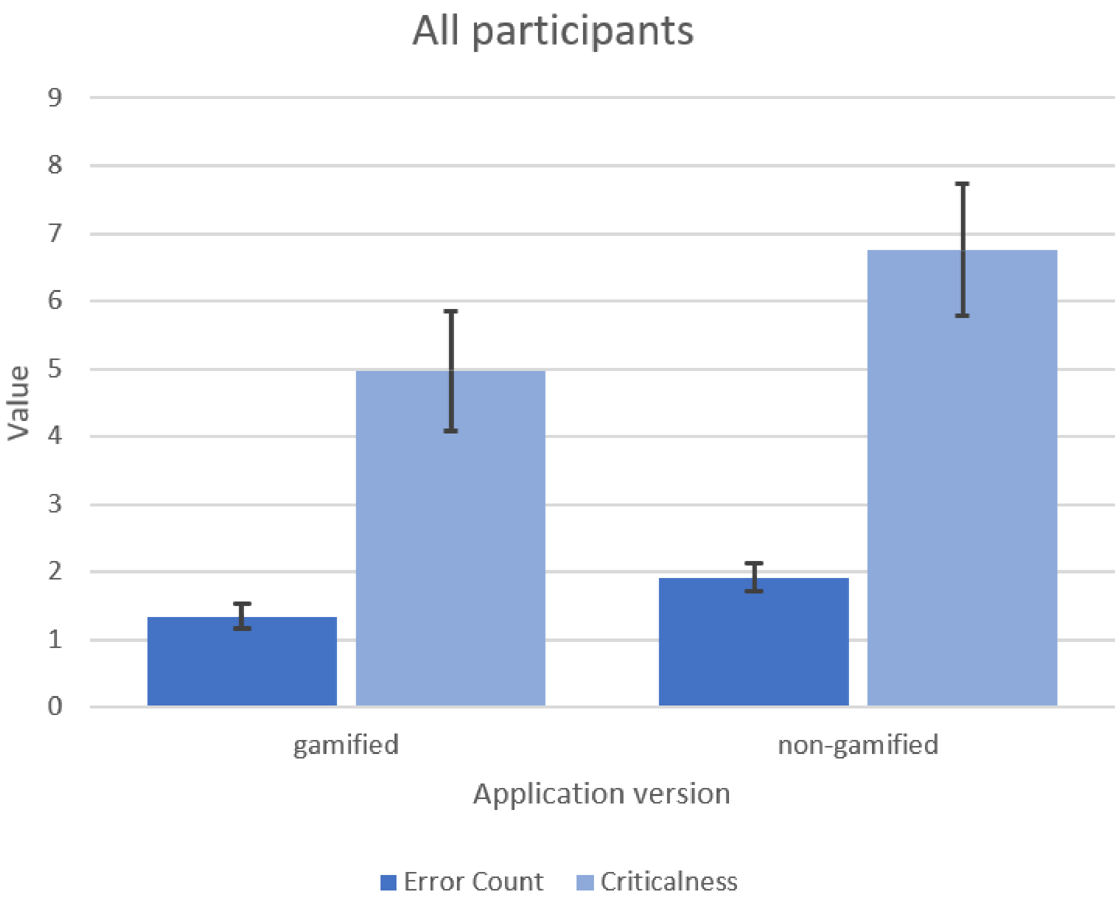


Figure 4.9.: Measurement of the mean error count and criticalness for both versions of the testing application, along with the standard error. Retrieved from Palmas et al. [Pal+19b]

The impact of gamification on the criticality of the errors made by the participants during the real-world test is illustrated in Table 4.4 and shows that there were no significant differences in the distribution of errors committed by the two groups, determined by a Chi^2 test with 3 degrees of freedom and an α level of 5%. The resulting Chi^2 value was 6.44, which was not significant (p=0.092) leading us to conclude that gamification does not appear to significantly affect the general criticality of the errors made by participants during real-world testing. Therefore, the null hypothesis H_0 in this context cannot be rejected [17].

[17] In real scenarios, gamification does not seem to affect the overall criticalness of participants' errors.

Group/Criticalness value	0-4	5-9	10-14	15-18
Exp. Group	17	11	1	3
Control Group	6	16	0	3

Table 4.4.: Criticalness errors committed by participants in the experimental and control groups during the real-world task. Retrieved from Palmas et al. [Pal+19b]

Based on the data obtained, subhypothesis H2 cannot be confirmed. However, the average combined criticalness of errors made by participants in the gamified training application was 4.97, indicating a 26.5 % decrease compared to the control group, whose mean was 6.76 (as shown in Fig. 4.9). These results suggest that the gamified training application may be effective in reducing the criticalness of errors made by participants.

Group/Number of Errors	0	1	2	3
Experimental Group (no VR exp.)	3	7	4	0
Control Group (no VR exp.)	1	0	7	6

Table 4.5.: Number of errors made by participants in the experimental and control groups with no prior VR experience during the real world task. Retrieved from Palmas et al. [Pal+19b]

The results in Table 4.5 show that gamification significantly affects the number of errors made by participants who do not have previous VR experience during the real-world task [18]. The Chi^2 test with 3 degrees of freedom and an α of 5% gave a Chi^2 value of 14.82 and a p-value of approximately 0.002. This Chi^2 values indicate that the null hypothesis H_0 can be rejected. In other words, gamification appears to have a significant impact on performance and consequently on the number of errors made by participants without previous VR experience.

This result shows that, for this subset of users, the gamified training application was effective in reducing the number of errors made by the participants. Specifically, the average number of errors per participant in the experimental group was 1.07, a 53.3% decrease from the mean of 2.29 in the control group. These results (see Fig. 4.9) confirm the subhypothesis H3 suggesting that the gamified training approach is effective in improving performance.

[18] A total of 28 participants are considered here who had no virtual reality experience before the study. Both groups consist of 14 participants each.

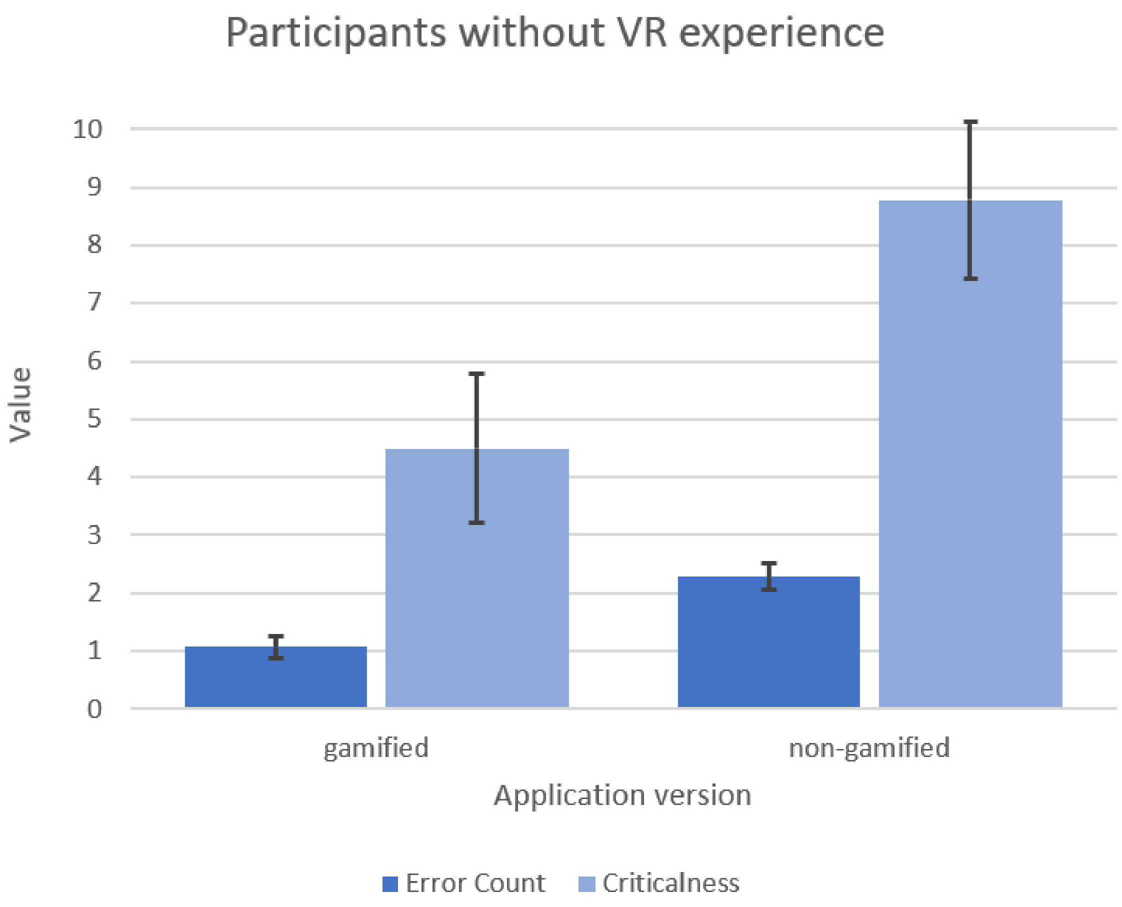


Figure 4.10.: Measurement of the mean number of errors and criticality for participants with no previous VR experience for both versions of the test application, as well as standard errors for each version. Retrieved from Palmas et al. [Pal+19b]

Based on the data presented in Table 4.6, it appears that gamification had a significant impact on the criticality of errors made by the 28 participants with no prior VR experience during the real-world task. A chi-square test was performed with 3 degrees of freedom and an alpha level of 5%. The Chi^2 value was calculated to be 12.9, which is above the critical value of 7.815. This corresponds to a p-value of about 0.005, which is lower than the α of 0.05. Therefore, the null hypothesis H_0 can be rejected and it is possible to conclude that gamification seems to impact the criticalness of errors made by the participants without prior VR experience when completing the assembly task in the real world.

Group/Criticalness value	0-4	5-9	10-14	15-18
Exp. Group (no VR exp.)	10	2	0	2
Control Group (no VR exp.)	1	10	0	3

Table 4.6.: Criticalness of errors made by participants without prior VR experience in the experimental and control groups during the real task. Retrieved from Palmas et al. [Pal+19b]

The results confirm and support subhypothesis H4. As shown in Figure 4.10, the mean combined criticalness of the errors made by the gamified training group was 4.5, a 48.1 % decrease compared to the control group, whose mean was 8.79. Consequently, these results indicate that the use of gamification in this training application reduced the severity of the errors made by these users.

4.4. Discussion and Future Works

The analysis of the data collected during this study did not support subhypotheses H1 and H2. In particular, these results did not show a statistically significant association between gamification and differences in error data between the two groups. This suggests that gamification may not have a significant impact in this particular context. More research is needed to better understand the role of gamification in relation to performance in VR training tasks.

However, the findings confirmed the H3 and H4 subhypotheses. In particular, the use of gamification elements seems to have had a statistically significant positive effect on the error and criticality distributions of participants with no previous experience in VR. These results underscore the potential of gamification to improve performance and improve learning outcomes in VR training for people with no prior VR experience. The study also confirms that gamification can influence learning behavior and can enhance knowledge transfer in VR training applications, which was the main hypothesis.

The results show that gamification had an impact on VR training. The experimental group was found to complete its training almost 12.2% faster than the control group and to have made fewer errors by a difference of 30.2%. Additionally, there was a significant drop in the criticalness value of 26.5%, again confirming that gamification is beneficial in this context.

Upon further analysis of the participants with no prior VR experience, it was observed that the gamified group had a significantly lower number of errors committed (53.3%) and a lower criticalness score (48.1%). This suggests that gamification is an effective tool and can be beneficial in training people, including those who have no previous VR experience.

In this study, a cymbal boom stand was used as a test object to the effectiveness of gamification in VR training. However, some of the volunteers who participated in the study indicated that at certain points during the task, they used intuitive solutions. This may have introduced noise into the recorded data. This raises concerns about the suitability of the cymbal boom stand as a test subject, as it was originally chosen because it was expected to be unfamiliar and unintuitive to the layperson. In future research, it may be beneficial to use more complex and random unusual objects as test objects, such as three-dimensional puzzles, to more accurately assess skills such as hand-eye coordination, multitasking, and memory recall.

A potential limitation of this study is the relatively short duration of memory retrieval tasks. Future research could examine the long-term memory abilities of participants in both experimental groups over a longer period of time. Additionally, the VR training program used in this study contained various gamification elements that may have contributed to its effectiveness. Further research could investigate the specific role of these motivational attributes in the effectiveness of the training application. It is important to note that the observed correlations between the training program and gamification may be specific to the particular combination of elements used in this study, rather than any single benefit.

In future research, it would be interesting to further investigate the effectiveness of different training approaches by implementing a larger and more diverse study design. One group could be trained using traditional two-dimensional paper manuals with written instructions, while other groups could use virtual and AR displays with dynamic instructions. In particular, the use of AR could provide a unique opportunity to explore the benefits of combining training and real-world tasks in a single environment. This study could provide valuable insights into the most effective methods to support learning processes. To fully understand the underlying mechanisms that contribute to these results and determine whether these findings can be generalized to other contexts and populations, more research is needed. Additionally, further investigations with larger sample sizes are necessary to validate these results and could have important implications for the development and implementation of training programs in a variety of areas.

4.5. Summary

In this study, a VR training application was developed to examine the impact of gamification on learner behavior. The results of a Chi^2 test indicated that gamification had a significant effect on the error and criticalness distribution of VR novices. Furthermore, the mean time spent in VR training, the number of errors committed, and the criticalness value were all better in the gamified group than in the non-gamified group, particularly among those with no prior VR experience. This investigation has made two main contributions to gamification research. First, a VR training application that could inspire further studies in this field, perhaps using similar approaches to implement gamification and user interactions, was developed. Second, by studying the introduction of gamification in a VR learning scenario, it was possible to obtain empirical evidence that gamification can influence the behavior of the learner in VR training applications. In general, these results suggest that gamification may be an effective tool to improve the efficiency and effectiveness of VR training, particularly for novices.

5. Virtual Reality Speech Trainer

As previously discussed in Section 2.1.3, the ability to communicate and present one's thoughts and ideas in a concise and organized manner is an essential soft skill for thriving in today's professional environment. It is also essential that a person has proficient public speaking skills in order to increase their confidence and their ability to persuade others. Consequently, public speaking has become increasingly relevant in a variety of contexts, including education, business [Van+20], and personal relationships [Pal+22].

Public speaking is considered a critical form of communication that allows individuals to share their ideas, thoughts, and opinions with a group of people. It is a process that requires the speaker to convey messages effectively while also engaging and captivating the audience. The success of public speaking is based on a combination of elements, including confidence, presence, voice projection, and body language. Together, these elements combine to create a powerful experience for the audience and ensure the success of the communication process [Pal+22].

The use of VR in public speaking training has the potential to provide a uniquely immersive experience that is difficult to replicate in real-world scenarios. By creating a virtual environment that simulates a real audience, speakers can practice their speaking skills in a realistic environment. The incorporation of body tracking, artificial intelligence, gamification, and speech recognition technology enables real-time feedback on the speaker's performance, allowing them to identify and address areas for improvement. The safe and controlled environment of VR can also help reduce anxiety and boost confidence when speaking in public [Pal+21; Pal+22]. In addition, VR can be used to simulate a variety of speech scenarios [1].

The purpose of this chapter is to provide an overview of two published research papers (see Section 5.2 and 5.3) that have examined the acceptance and effectiveness of VR-ST and its evolution into a gamified version with direct feedback. The following sections contain excerpts and adaptations of the texts of these publications.

5.1. Background

According to the discussions presented in the previous chapters, individuals are expected to be able to apply new skills and attitudes acquired through training programs effectively in a variety of situations. In this context, it is important to consider a central concept of learning theory, the transfer of learning. This refers to the ability to apply previously acquired knowledge and skills to different situations [MG95; Pal+19a]. A key component of any successful

[1] For example, presenting in a large auditorium or speaking at a significant business meeting gives speakers experience in a variety of public speaking situations.

training program is to ensure that learners are able to apply what they have learned to real world scenarios.

Within this frame, when applied to training programs, XR technology can provide several benefits. A summary of the benefits associated with extended reality training in corporate and educational settings can be found in Palmas et al. [Pal+22], as follows:

- Provide more realistic and true-to-life learning environments
- Tailor the learning experience to the individual
- Provide more engaging and immersive learning experiences
- Empower learners to practice in a safe and controlled environment
- Assess learners' progress and understanding in real-time

Accordingly, VR facilitates a sense of presence and embodiment in a virtual environment [Sla+06], which has great potential for improving communication skills and the transfer of those skills [Sch+18]. Moreover, VR offers a controlled environment in which people can be gradually exposed to feared stimuli. This exposure can lead to habituation to fear and a reduction in avoidance behaviors [Pal+19a].

Fear of public speaking has been classified as both a social phobia and an anxiety disorder [Ass+94] and behavioral exposure therapy has been shown to be an effective treatment for reducing anxiety symptoms associated with it. This therapy involves exposing individuals to increasingly challenging public speaking situations in a safe and controlled environment, while also practicing routine presentation behaviors and techniques to reduce the emotional response to public speaking. Through consistent repetition and practice, individuals can develop the skills and confidence necessary to make successful public presentations [Pal+21] (see Tab. 5.1).

Body Language: During a speech, it is necessary to adopt an open posture, as well as firm footing, to attract the attention of the audience and to display self-confidence [Bir09; Mat12; PS04].
Eye Contact: Giving a speech requires constant eye contact with the audience, so that the audience feels addressed and follows the presentation attentively [Gru83; KT80].
Language: For a successful presentation, participants should exhibit pronounced speech volume and fluid speech flow, which can be achieved by correct body posture and steady breathing. This gives the speech a pleasant speech melody, making listening enjoyable. The speaking speed should be based on the guideline value of 100 to 150 words per minute in order to allow the audience to receive and process the relevant information. In addition, it is important to avoid so-called filler words, as they hinder effective communication, lead the audience to question the speaker's competence, and reduce the audience's attention [Gut08; CW98].

Table 5.1.: Summary of the criteria of successful public speaking. Adapted from Palmas et al. [Pal+21]

The use of VR for behavioral exposure has been identified as a potential tool to gradually and systematically expose individuals to challenging situations in a safe and controlled environment, so they can face their fears and build confidence and resilience to real-world challenges [Gri+06; Mor+15; Pal+21; Riz+13]. Furthermore, the use of VR technology in psychological applications has proven to be efficacious across a wide range of disorders and is a promising area of research [PS20]. For example, VR interventions have been consistently found to reduce self-reported physiological indicators of public speaking anxiety and have shown promise in reducing agoraphobia [2], acrophobia [3], and aviophobia [4] in clinical settings [Pal+19a].

Several therapeutic applications of VR have also been developed, with VR biofeedback and VR-based counselors and therapists currently among the most widespread applications of this technology. Some of these examples involve the use of interactive characters, including counselors, diagnostic tools, and the ability for clients to share virtual spaces with other people within a VR setting. Furthermore, in recent years, VR applications such as those mentioned above have been developed and studied, often with encouraging results [TST19]. Consequently, VR offers opportunities to practice new skills in a safe environment, which can lead to the generalization of skill development for real-world situations.

Psychologists have found that when applying VR to treat anxiety disorders, any representation that approximates the patient's anxiety or stress trigger is sufficient to activate it. Patients respond similarly to cartoon representations of what they fear when confronted with real-world situations in VR [SC18b]. However, when representing people in VR environments, it is worth considering the uncanny valley effect [Pal+19a]. Further considerations must also

[2] Fear of embarrassing situations that cannot be escaped.
[3] Heights-related fear.
[4] Fear of flying.

be taken into account in this context. People who are used to computer games will probably have high expectations for the graphical quality of the visual representations in therapeutic virtual worlds. A lack of quality representations could undermine the validity and credibility of the application [SC18b].

Overall, VR seems to provide an effective platform for conscious practice because of its ability to create consistent learning environments in which individuals can engage repetitively in problem solving, experimentation, and exploration of new approaches and solutions. The use of interactive learning methods is often accompanied by game design elements, which in many cases positively support learning mechanisms and learning outcomes. Additionally, feedback is a crucial component of both gamification and educational interventions [Pal+21].

As a way of clarifying the relationship between gamification and learning, Landers et al. [Lan14] proposed the theory of gamified learning. While this theory suggests that gamification can indirectly improve learning outcomes (see Tab. 5.2), it does not specify which elements of game design are effective in supporting and triggering learning mechanisms [SH19].

Learning Outcomes		
Cognitive Learning	*Motivational Learning*	*Behavioral Learning*
Conceptual Knowledge	Intrinsic Motivation	Technical Skills
Knowledge of Facts	Dispositions	Motor Skills
Principles	Preferences	Competences
Application-Oriented Knowledge	Attitudes	Performance on a Specific Task
Strategic Knowledge	Engagement	
Situational Knowledge	Feelings of Confidence	

Table 5.2.: A brief overview of learning outcomes. Retrieved from Palmas et al. [Pal+21]

In addition, debriefing sessions can also be effective to create learning effects. For example, serious games have also proven to be effective in facilitating learning through debriefing sessions in which players receive feedback and have the opportunity to reflect on and learn from their mistakes during the game [Pal+19a].

Acceptance of technology is a critical factor in the adoption and success of VR training programs, which can be influenced by a variety of factors. Studies have found that people with phobias tend to prefer VR exposure therapy to real-world exposure to counter anxiety-provoking stimuli. However, people without previous VR experience tend to prefer traditional therapy methods over VR interventions. This suggests that preference for VR-based interventions may be influenced by previous experience with the technology [Pal+21].

In summary, VR public speaking training can effectively simulate the experience of speaking in front of a real audience and has the potential to facilitate the acquisition of public speaking skills and behaviors. Participants in VR public speaking simulations have shown similar responses to real-world situations, suggesting that VR could be a useful tool for public speaking and other soft skills training. Additionally, research has shown that the way the virtual audience reacts in VR can impact how the participant perceives the public speaking intervention [PSB01; Sla+06]. Moreover, the acceptance of such applications is considered a basic requirement for their use in the real world [Pal+22], and the effectiveness of this training depends both on user acceptance and organizational support [Pal+19a].

5.2. VR-ST Version 1

The following sections are partially taken and adapted from the publication "Acceptance and Effectiveness of a Virtual Reality Public Speaking Training" presented by Palmas et al. [Pal+19a]. The objective of the study was to develop and evaluate the acceptance and effectiveness of VR-ST among participants. Additionally, it was investigated whether it is feasible to provide a report on the participants' performance immediately after the VR-ST session. The final aim was to assess the impact of the VR-ST on the subsequent public speaking performance of the participants.

5.2.1. Implementation

Application: To develop the VR-ST the Unity3D game engine was used. In addition, a VR environment that replicates a typical business meeting room was created. This closely resembled the physical seminar room in which participants gave their live presentations during the third phase of the study. The VR environment contained three avatars representing different characters within the virtual audience, and the attention of these characters was determined by a real-time audience attention system. Character and environment models were designed to look realistic (see Fig. 5.1).

Figure 5.1.: A female avatar (left) and a male avatar (right) from the participant's perspective in VR-ST. Retrieved from Palmas et al. [Pal+19a]

Tracking: To display the VR-ST and interact in its environment, an HTC Vive HMD, VIVE controllers, and two external foot trackers were used. This equipment was able to reassemble the participants' gestures into human-like avatar models [5] during the VR presentation by using inverse kinematics. Compared to a full motion capture system, this hardware and tracking approach with 6-Degrees-of-Freedom (DoF) allowed position metrics to be measured during the virtual presentation while reducing latency and task load [Pal+19a].

Speech: Through the Unity engine, it was possible to access the head-mounted display 's built-in microphone to obtain spectral data of the captured voice and calculate decibel levels. To facilitate the transcription of spoken presentations in English, the IBM Watson API was used. This API includes markers for instances of hesitation or pause, which can be filtered using regular expressions to accurately identify non-lexical filler words, as listed in Table 5.3. Using the generated transcript, the number of words and the time elapsed between the first and last words were calculated to estimate the user's current words per minute (WPM) rate. To determine the average WPM for the entire speech, the total number of words was divided by the total length of the speech. The IBM Watson API provides a confidence score for each identified word, reflecting the reliability of its prediction based on pronunciation clarity.

[5] The avatar models resembles a human male or female.

like	hum (hesitations)	thing	things	see
you know	right	as I said	for instance	stuff
well	so	for example	you know what I mean	stuffs

Table 5.3.: System-checked filler words during presentations. Retrieved from Palmas et al. [Pal+19a]

Body Language Based on the head position in relation to the floor in the room, a heat map of the user's body position was generated. The heat map was calculated by comparing the time spent at a given location to the maximum amount of time spent at any location within the 3D environment. To measure eye contact with the audience in a 3D environment, raycasts were emitted from the eye-level of the head-mounted display and intersect with objects faced by the participants. This allowed us to track the time each participant faces each object in the 3D environment. The resulting data can be used to modulate the responsive virtual audience's attention system and generate a realistic response to the participant's performance. To determine the rotation of the headset in relation to the center of the audience within a meeting room, direction and target vectors were utilized to calculate the angle between them. This angle was then compared to configurable threshold rotations within the Unity engine. In addition, a similar approach was used to collect data on participants' gaze direction [6].

Audience Attention The effectiveness of a presentation is often determined by the level of attention it elicits from the audience. This audience's attention value can be quantified using various metrics, such as the speaker's rate of speech [7], use of filler words and hesitations, body language [8], vocal volume [9], and eye contact with audience members [10]. By analyzing these factors, it was possible to gain insight into the overall quality of the presentation and how well it engaged the audience.

5.2.2. Phases of the Study

This study consisted of three distinct phases (see Fig. 5.2):

- **Phase 1:** Introduction
- **Phase 2:** VR training
- **Phase 3:** Live presentation session

The study was conducted in English to accommodate the international diversity of the group of participants, and all participants were treated equally and tested individually. Each

[6] I.e. up, down, and forward.
[7] Too slow or too fast in terms of WPM.
[8] Hands position, body rotation, viewing direction of gaze.
[9] Too loud or too quiet.
[10] Balanced eye contact between the whole audience and the individual characters.

participant completed three questionnaires at different times during the study: the first after the introduction, the second after the VR training, and the third after the live presentations. These questionnaires enabled an assessment of participants' acceptance of VR as a training method and their self-reported improvements over the course of the study.

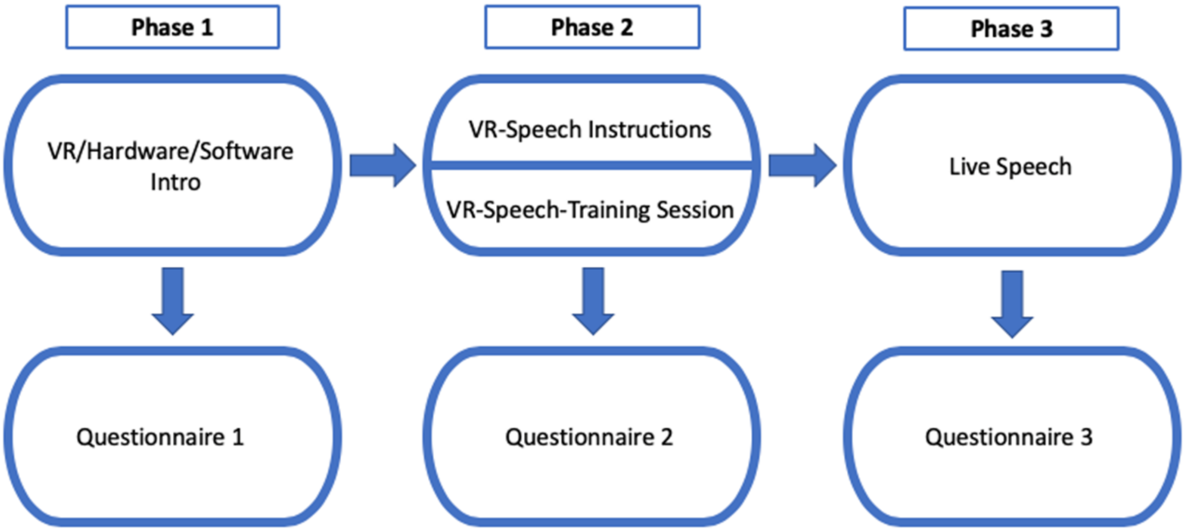


Figure 5.2.: An overview of the study's phases in chronological order. Retrieved from Palmas et al. [Pal+19a]

In this study, Likert scale questions and open-ended questionnaires were used to collect data from participants. The Likert scale questions were presented on a five-point scale and required the respondents to indicate the extent to which they agreed or disagreed with a statement [11]. Open-ended questions were used to gather more detailed and specific answers and feedback from the participants.

The phases can be summarized as follows:

- **Phase 1:** In this initial phase, participants received an explanation of the VR-ST and its hardware components. Each participant then prepared a presentation to be given for the VR-ST in English, using the same materials as in the final live session.
- **Phase 2:** The intended use of VR-ST was explained for each participant prior to the start of the VR training. After choosing an avatar in the VR environment, participants were asked to rate the difficulty of each slide in their presentation, with low, medium, and high levels corresponding to the time the participant wished to allocate to each slide. This process aimed to improve time management skills and ensure balanced attention from individual audience members during the VR-ST session. To begin the

[11] For instance, the participants were asked to rate their own presentation skills on a scale from very bad (1) to very good (5). Additionally, the participants were asked if using VR-ST had the potential to improve their presentation skills.

VR-ST session, participants clicked the "Go to Office" button and were transported to a virtual office setting with three individuals seated around a table, where a laptop was positioned in front of the participant. To start the training, the participant clicked the "Start" button on the virtual computer screen, and the timer started. During the VR-ST session, participants could view their presentation on the laptop or on a screen behind them. The training was completed by clicking the "Stop" button, and the total duration of the VR-ST session (excluding the setup phase) was approximately five minutes per participant. Following the VR-ST session, all participants received a detailed analysis, including personalized feedback, in the form of a PDF [12] report via email.

- **Phase 3:** During this phase, participants gave a presentation in a real-world environment using the same materials used in Phase 2 in front of a real audience. It is important to note that the physical environment and context of the presentation were very similar to the VR environment used in Phase 2. This allowed for a direct comparison between the two scenarios and enabled the assessment of the effectiveness of the VR training on the participants' performance in a real-world setting.

5.2.3. Metrics

The VR-ST fully and automatically evaluated a series of measures listed in Table 5.4 and presented to the participants in their report at the end of Phase 2.

Metric	Variables	Optimal Level
Timing	Self-estimation of the presentation's time and actual presentation time	Elapsed time = estimated time = max. time
Transcript	Speech transcription (accuracy)	Accurate transcript, no filler words
Eye Contact	Viewed objects in virtual environment	Audience exclusively
Voice	Speaking volume	Balanced
Positioning	Subject position in virtual environment	Subject moves around in the virtual environment
Filler Words	Hesitations and fillers	No filler words
Body Language	Body facing direction, hand position	Facing audience, hand position in TV-window

Table 5.4.: These metrics were used to generate reports for each participant and for the adaptive attention system for the audience. Retrieved from Palmas et al. [Pal+19a]

These metrics were also used by the adaptive attention system to monitor audience engagement and reactions in real time. During a VR-ST session, participants were encouraged to analyze their performance and adjust their public speaking techniques based on audience

[12] Portable document format.

engagement. This may include restoring eye contact, adjusting the pace of their speech, changing their posture or gestures, and changing their position in space. Signs of audience disengagement (see Fig. 5.3) can include averting eye contact, displaying an insincere smile, adopting defensive body language such as crossing their arms and tightening their fists, fidgeting with objects or their phones, checking the clock, and exhibiting fidgety behavior and nervous movements with their hands.

Figure 5.3.: An example of a virtual audience that is engaged (left) and bored (right). Retrieved from Palmas et al. [Pal+19a]

It was hypothesized that one of the key benefits of VR training is the ability to provide feedback in a personalized and innovative way [Sch+18]. With VR-ST, this feedback is provided and generated as a result of data collected during the VR-ST session. In the report for the participants, the following metrics were discussed in detail, and an explanation of how to interpret them was given:

- **Timing:** The timing metric has three components: elapsed time [13], estimated time [14], and maximum time [15]. These three components of the timing metric provide information to participants about different aspects of the duration of the VR presentation.
- **Transcript:** Based on what was identified by voice recognition, the transcription is shown. Filler words are displayed in red.
- **Eye contact:** Objects viewed by participants during a presentation are tracked. The collected data are then displayed in a pie chart that is divided into categories such as audience, laptop, screen, floor, and others. The chart shows the proportion of objects in each category that were viewed during the presentation. In addition to the pie chart, a heatmap was also used to visually represent where the participants directed their gaze during the presentations. In the heatmap, more frequent gazes on different objects are represented by green and red shades, while less frequent gazes are represented by blue shades (see Fig. 5.4). This information is presented in two formats, the pie chart and the heat map, which provide insight into which objects and areas caught the attention of

[13] The actual duration, also known as the elapsed time, is the duration of the virtual reality presentation from start to finish.

[14] The estimated time is a prediction of how long the presentation will take based on the complexity of the content.

[15] The maximum time is the specified maximum duration and selected time limit for the presentation.

the participants during the presentations. This information enables an understanding of the objects and areas of the virtual environment that were most interesting to the participants.

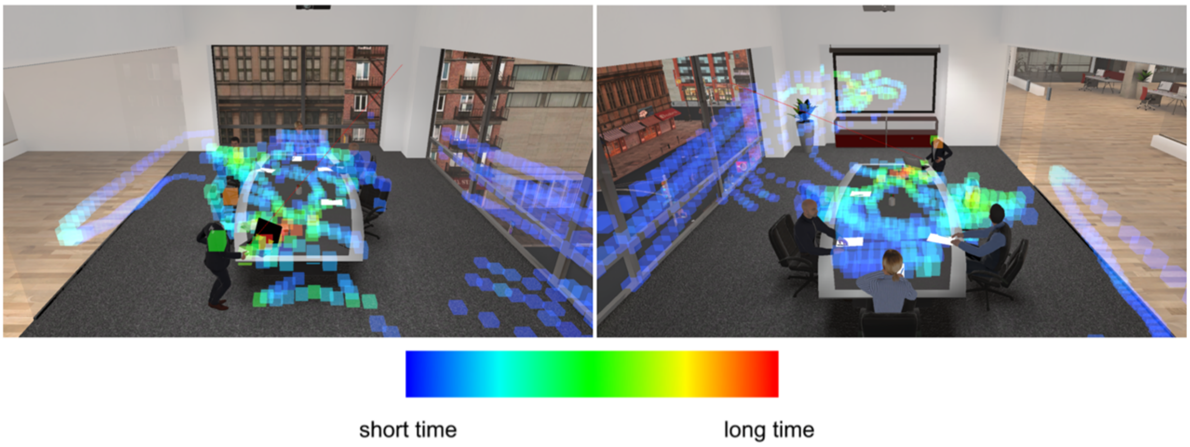


Figure 5.4.: The heatmap shown above is an example of what a participant viewed. Retrieved from Palmas et al. [Pal+19a]

- **Voice:** Speech quality was rated on three dimensions: volume, confidence, and WPM. The volume has been presented as a chart showing fluctuations and the average volume. A mean value around zero indicates adequate volume, which is loud and clear, while values below and above zero indicate insufficient and excessive volume. Speaker confidence was assessed based on confidence score and pronunciation accuracy. A graph has also been provided to represent the WPM, with a mean of 100–150 WPM considered a desirable speaking rate (see Fig. 5.5).

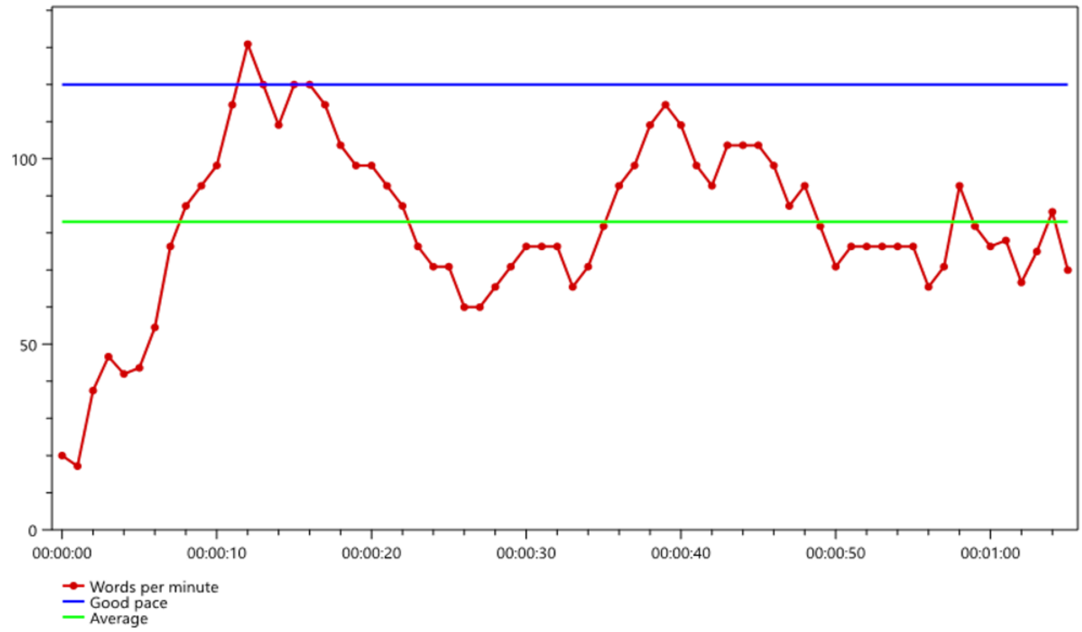


Figure 5.5.: An example of a graph showing words per minute in a report. Retrieved from Palmas et al. [Pal+19a]

- **Positioning:** The standing positions of the participants during their presentation are displayed on a heat map (see Fig. 5.6).

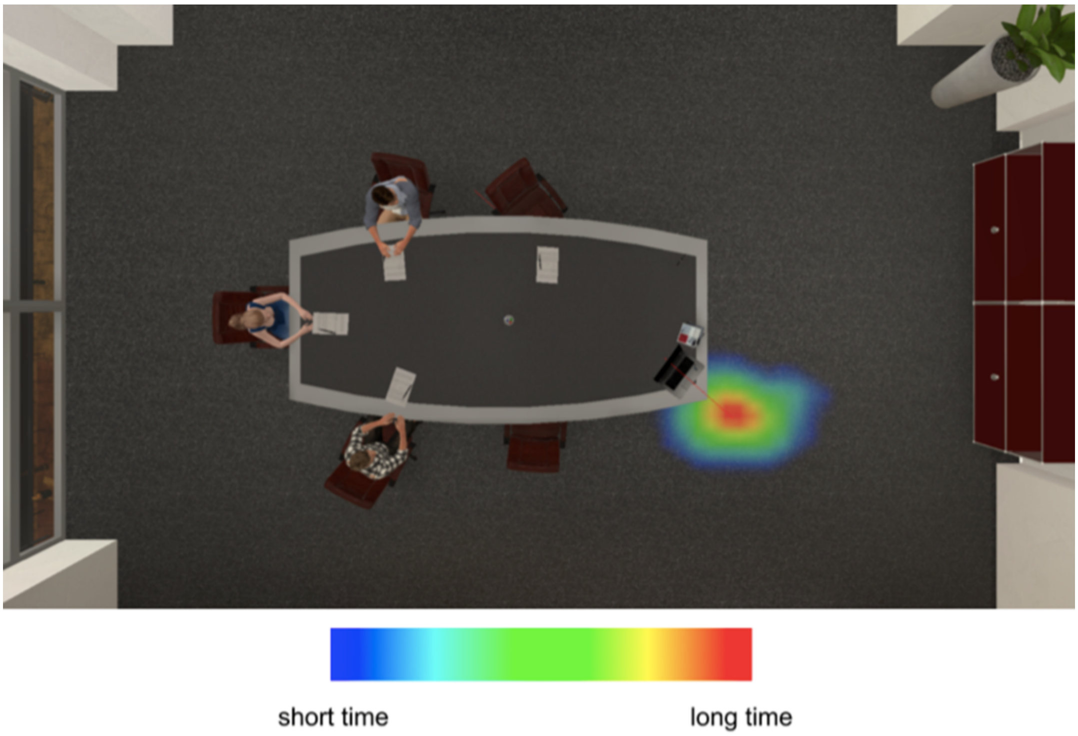


Figure 5.6.: An analysis of the participant's physical movement based on a heatmap. Retrieved from Palmas et al. [Pal+19a]

- **Filler words:** The transcript includes a list of filler words [16] used during the presentation, along with their frequency.

[16]The filler words are written in red throughout the transcript.

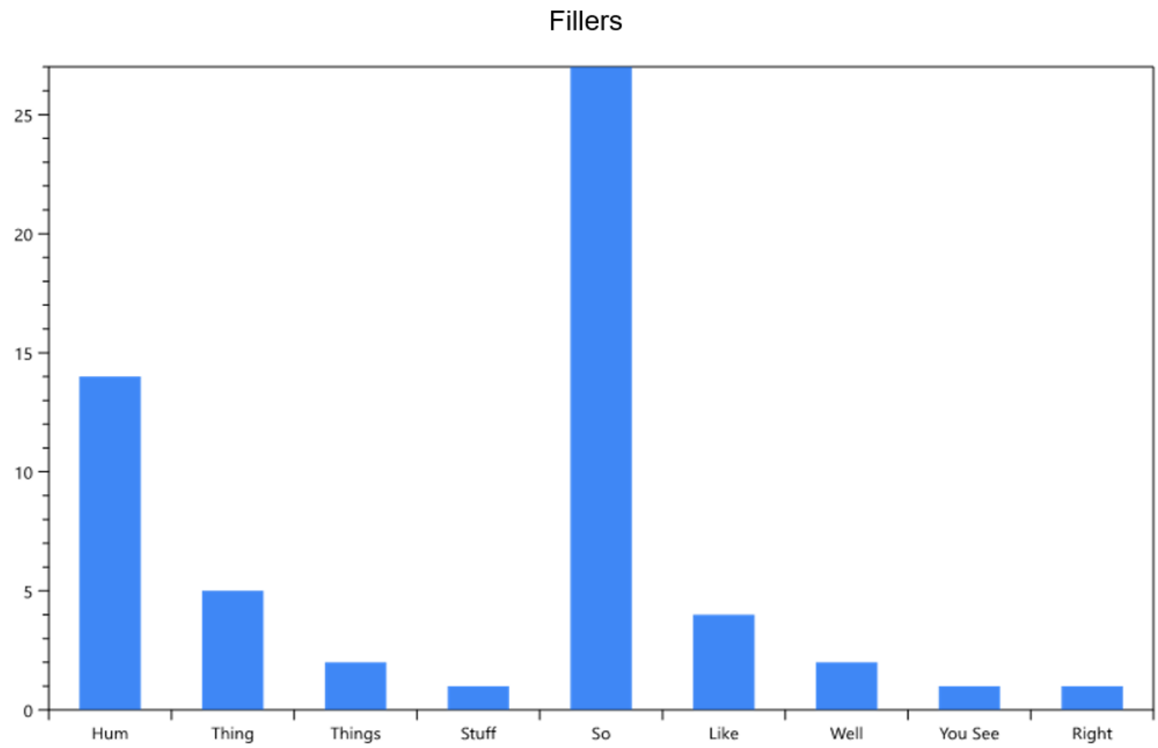


Figure 5.7.: A report example with filler words. Retrieved from Palmas et al. [Pal+19a]

- **Body language:** Several metrics were used to assess participants' nonverbal behavior, such as eye gaze, hand position, and body orientation. Pie charts were used to present these metrics. They indicate how often the speaker looked forwards, upwards, or downwards, held their hands at different heights, and oriented their body toward or away [17] from the audience. The pie charts provide a clear and concise visual representation of the participants' body language (see Fig. 5.8).

[17] Sideways or backwards to the audience.

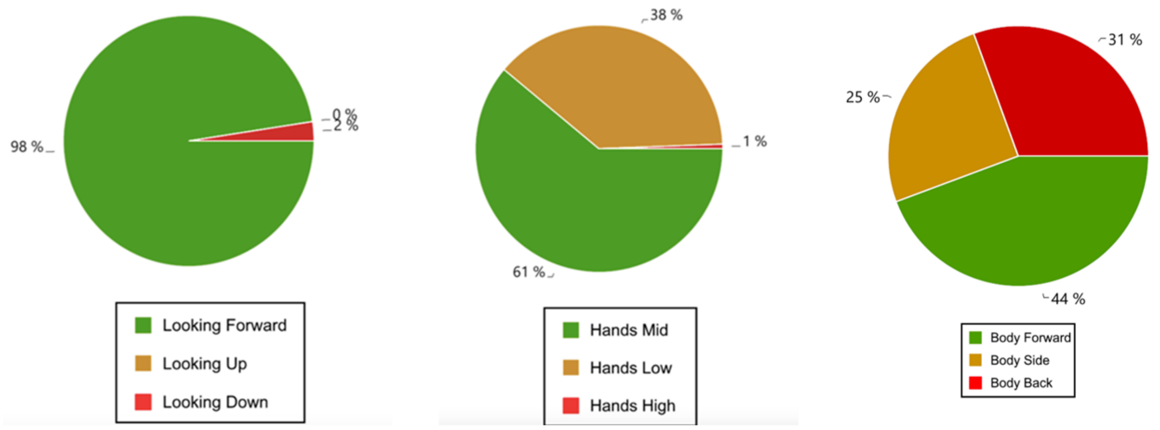


Figure 5.8.: An example of an analysis of body language of a report, which provides some indication of performance. Retrieved from Palmas et al. [Pal+19a]

- **Response analysis:** The data presented in the Figure 5.9 reflects the attention shown by the virtual audience during a presentation. Several factors, including eye contact, voice, gestures and body language contribute to audience engagement [18].

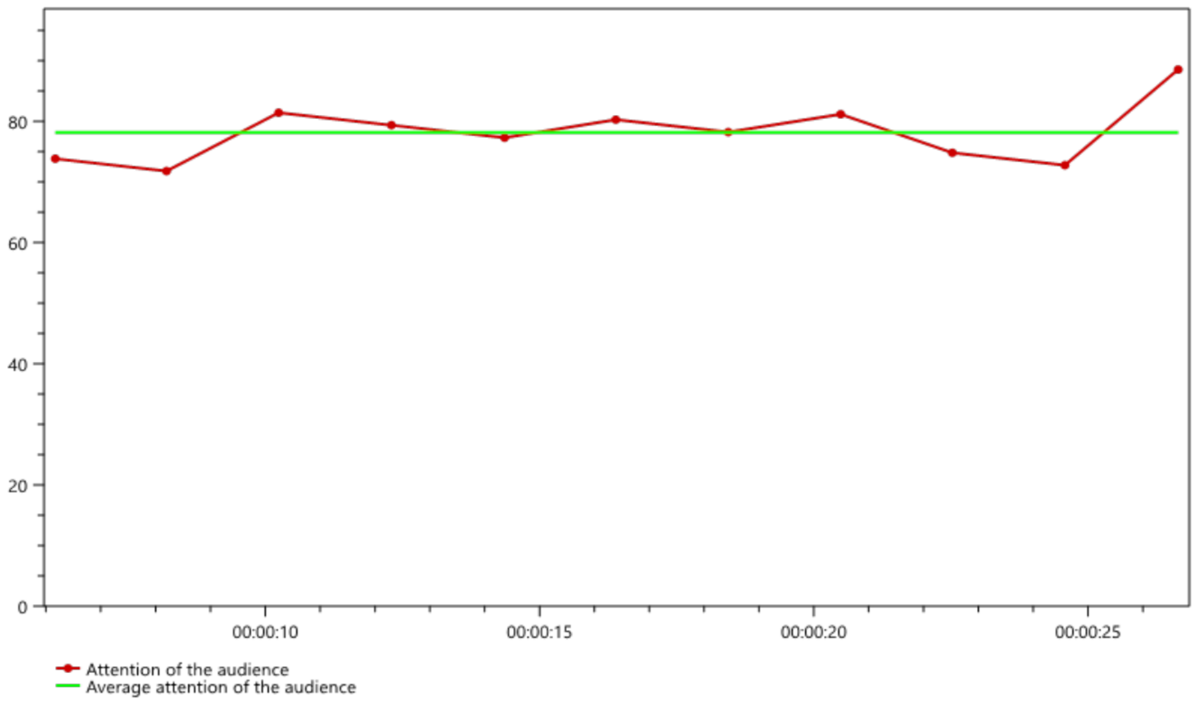


Figure 5.9.: An example of the fluctuating attention of the virtual audience during the presentation. Retrieved from Palmas et al. [Pal+19a]

[18] By examining these variables, it is possible to gain insight into the ways in which non-verbal behaviors impact audience attention during a presentation.

5.2.4. Sample and Results

Forty-four MBA students [19] participated in this study, with a gender distribution of 15 females and 29 males. The participants were between 24 and 50 years old, with a mean age of 34.8 years.

All participants were employed at the time of the study and had an average experience of 3.4 years in their respective companies. Data collection for this study was based on participant responses at the end of each phase of the study. The average number of years of work experience among the participants was 10.7. Of the 44 participants, 25 had previously attended presentation training or course, while the remaining 19 had no prior knowledge of presenting.

Eight of the 15 female participants had previously completed presentation training; the remaining 7 had not. Of the 8 people who had previously been trained, 5 rarely used VR, while the rest had never used VR before. In addition, half of the participants had never used VR, and the other half only rarely used it.

All but one participant wanted to improve at least one of the following presentation skills:

- Body language
- Audience engagement
- **T**ime management
- **V**oice
- **C**onfidence

As shown in Table 5.5, the standard deviation was high for both WPM and filler words, with an average rate of 138.18 words per minute and an average frequency of 33.16 filler words. A Pearson correlation coefficient (R) of 0.1089 indicates a weak relationship between WPM and filler words, suggesting that an increase in WPM does not necessarily lead to an increase in filler words.

	WPM	**Filler Words**
Sum	-	1459
Mean	138.1818	33.159
Variance	469.8731	785.95
Standard Deviation	21.6765	28.0348

Table 5.5.: Filler words. Retrieved from Palmas et al. [Pal+19a]

The study results showed that female participants who had received prior presentation training or participated in a course maintained eye contact with the audience 57.9% of the

[19] The participants were students enrolled in a Master of Business Administration program for executives.

time, while participants without prior training maintained eye contact only 35.71% of the time (see Tab. 5.6). Additionally, both female and male participants who rarely used VR had a higher percentage of eye contact with the audience than those who had never used VR before.

These results suggest that prior presentation training and VR use may be associated with increased eye contact with the audience.

Eye contact with the Audience		
Use of VR	**Never(%)**	**Rarely(%)**
Male	37.85	54.78
Female	51.77	57.87

Table 5.6.: Eye contact. Retrieved from Palmas et al. [Pal+19a]

The results of the study showed that although participants were able to move freely in the physical environment, they generally remained stationary at the intended starting position. Table 5.7 shows that the participants showed high compliance with the correct attitude during their speeches, achieving an average of 80.22% in terms of audience attention.

These results indicate that participants were able to effectively engage their audience while maintaining the appropriate attitude.

	Mean(%)
Hands position (middle)	81.90
Body Direction (forward)	80.00
Looking Direction (forward)	95.90
Confidence	76.79
Audience Attention	80.22

Table 5.7.: Body language. Retrieved from Palmas et al. [Pal+19a]

The self-evaluations of the participants showed that the use of VR-ST was effective in helping the majority overcome their fear of public speaking, with 46% mostly agreeing and 18% totally agreeing with it. Furthermore, 80% of the participants believed that multiple VR-ST sessions would likely improve their presentation skills, with 41% stating “very much” and 39% saying “much”. The majority of participants (92%) reported having fun and enjoying VR-ST, with 72% rating it 5 out of 5 and 21% 4 out of 5.

These results suggest that VR-ST could be an effective tool to overcome fear of public speaking and improve presentation skills, and the participants appreciated it greatly.

According to the results of the third questionnaire, 81% of the participants found feedback on their reports helpful in improving their presentation skills, with 34% rating it very helpful and 47% rating it helpful. With a median and mode rating of 5, the participants also found the use of VR technology and VR-supported training to be very useful. Of the 44 participants, 42 said they had improved at least one presentation skill in one area, such as voice, body language, audience engagement, confidence, and time management.

These results show that feedback and VR-ST helped participants improve their presentation skills.

5.2.5. Discussion and Future Works

In this study, self-reported data on the effectiveness of the VR-ST were collected. The results showed that VR-ST was generally well received and was found to be effective by most participants. However, some participants mentioned difficulties getting used to the technology and the short duration of the training.

These results form a basis for future research on the objective effectiveness of VR-ST. However, it is important to recognize the limitations of relying on self-reported data, as subjective experiences and perceptions may not always accurately reflect objective results. Additionally, the limited exposure to VR-ST may have affected participants' ability to fully adapt to the technology. More research using objective measures and longer training times is needed to fully assess the effectiveness of VR-ST. However, the positive acceptance rate observed in this study suggests that VR-ST has potential as a useful communication skills training for public speaking.

At the end of the third phase, 95% of the participants reported an improvement in their presentation skills. This suggests that VR-ST helped participants develop their presentation skills. Additionally, it was observed that female participants who had previous experience with real-world presentations spent more time making eye contact with their virtual audience. This result supports the idea that learning transfer can take place between the virtual and real worlds.

It is important to note that the sample size of 44 participants was relatively small and future research with a larger sample size would be needed to confirm these results. Furthermore, the fact that 5% of the participants did not feel their skills improved suggests that further investigation is needed on potential factors that may impact the effectiveness of VR-ST.

In order to thoroughly assess the effectiveness of a single session of VR-ST on public speaking skills, it is necessary to conduct multiple sessions. This is supported by participant feedback that indicated a desire for additional training sessions to improve. Furthermore, the report was accepted by participants and appears to support the learning effects of VR-ST when used in conjunction with it. Although the present study provides early evidence of the potential effectiveness of VR-ST, more research is needed to fully understand to what extent this training can improve real-life public speaking skills. This limitation should be considered when interpreting the results of the current study and planning future research in this area.

The results suggest that VR-ST may be particularly effective in helping participants overcome a fear of public speaking. Most of the participants (80%) indicated that they believe that VR-ST has the potential to be a valuable training method for companies. These results are consistent with previous research suggesting that VR can provide a safe and immersive environment for skill development. However, it should be noted that some participants expressed concerns about the feasibility of implementing VR-ST in their own organizations, citing issues such as skepticism or conservative decision-making in corporate environments [20]. These observations highlight the potential challenges that may arise when adopting VR-ST as a training method and suggest that further research may be needed to understand the factors affecting its acceptance by organizations. Despite these limitations, the results of this study suggest that VR-ST has the potential to be an engaging and effective tool that can be fun and help improve public speaking skills, especially when designed to match the skill level of individual participants.

There are several potential directions for future research on VR-ST. One possibility is to expand the control group to enable it to more accurately assess the transfer of acquired skills. This could include adding a second VR-ST session to allow more time to become accustomed to the technology and reduce the fear of making mistakes when using it. Another option is to conduct a long-term intervention study, which could use objective metrics to compare the results of the participants over several weeks. This would provide valuable information on the sustained impact of VR-ST on skill development. Additionally, it may be worth exploring the potential of a gamified version of VR-ST to improve training efficiency and engagement. However, this implementation must be thoroughly tested for efficiency and acceptance by the participants. In general, there are numerous opportunities for future research on VR-ST, and these findings have the potential to greatly advance the understanding of VR as a tool for skill development.

5.2.6. Summary

The acceptance of VR-ST is critical for its effectiveness as a tool for skill development, particularly in the area of public speaking. In this study, a group of executive MBA students demonstrated acceptance of VR-ST and reported positive learning outcomes. These results suggest that VR-ST has the potential to support learning and improve communication skills if accepted by users. However, it is important to note that acceptance is necessary not only on an individual level but also on an organizational level. For companies to take full advantage of VR-ST and enable their employees to improve their performance, they must be willing to embrace this technology and integrate it into their training programs. In general, the results of this study demonstrate the effectiveness of VR-ST as a training tool to develop communication skills, but they also underscore the importance of acceptance for successful implementation.

5.3. VR-ST Version 2

Parts of the following sections have been extracted and adapted from the study “Virtual Reality Public Speaking Training: Experimental Evaluation of Direct Feedback Technology

[20] Some participants stated that it could not be implemented in their own organization “because of conservative decision makers and skepticism” or the company being “too small, too conservative”. Against this background, it becomes clear that the biggest challenge in establishing this type of virtual reality training is the general acceptance by companies and not the individual.

Acceptance” by Palmas et al. [Pal+21]. Data were collected by Reinelt [Rei19] for her master’s thesis. The purpose of this study was to compare the effect of a version of VR-ST with direct feedback versus a simulation-based version on technology acceptance based on the TAM.

In the following sections, this research, the further developed VR-ST, and two important concepts related to this research (direct feedback and TAM) are examined in depth.

5.3.1. Direct Feedback

The importance of feedback from superiors and colleagues in business has long been established. Feedback not only provides employees with the opportunity to develop their skills and increase their potential but has also been linked to greater employee engagement. In fact, Gallup research has shown that employees who say they regularly receive meaningful feedback are four times more likely to be engaged than those who do not receive such feedback [MB20].

Feedback is an essential aspect of learning [HT07; Van+20] and all training programs and assessments of non-verbal skills [Pal+21; Tan+16], serving as a means of influencing a user’s understanding by providing information following an input. This information allows the user to compare the results of their actions with a desired outcome, ultimately shaping their perception [Ber19; Mor04; Pal+21; Tuc93]. In general, it is important to provide both targeted practice and targeted feedback to facilitate learning. This can be achieved by implementing goal-oriented practice paired with targeted feedback. This principle underscores the importance of productive practice and effective feedback in the learning process [Amb+10].

According to Ambrose et al. [Amb+10], it is possible to conceptualize practice and feedback as a cycle. Learners can refine and improve their knowledge and skills when practice and feedback are balanced, allowing them to practice consistently and receive targeted feedback (see Fig. 5.10).

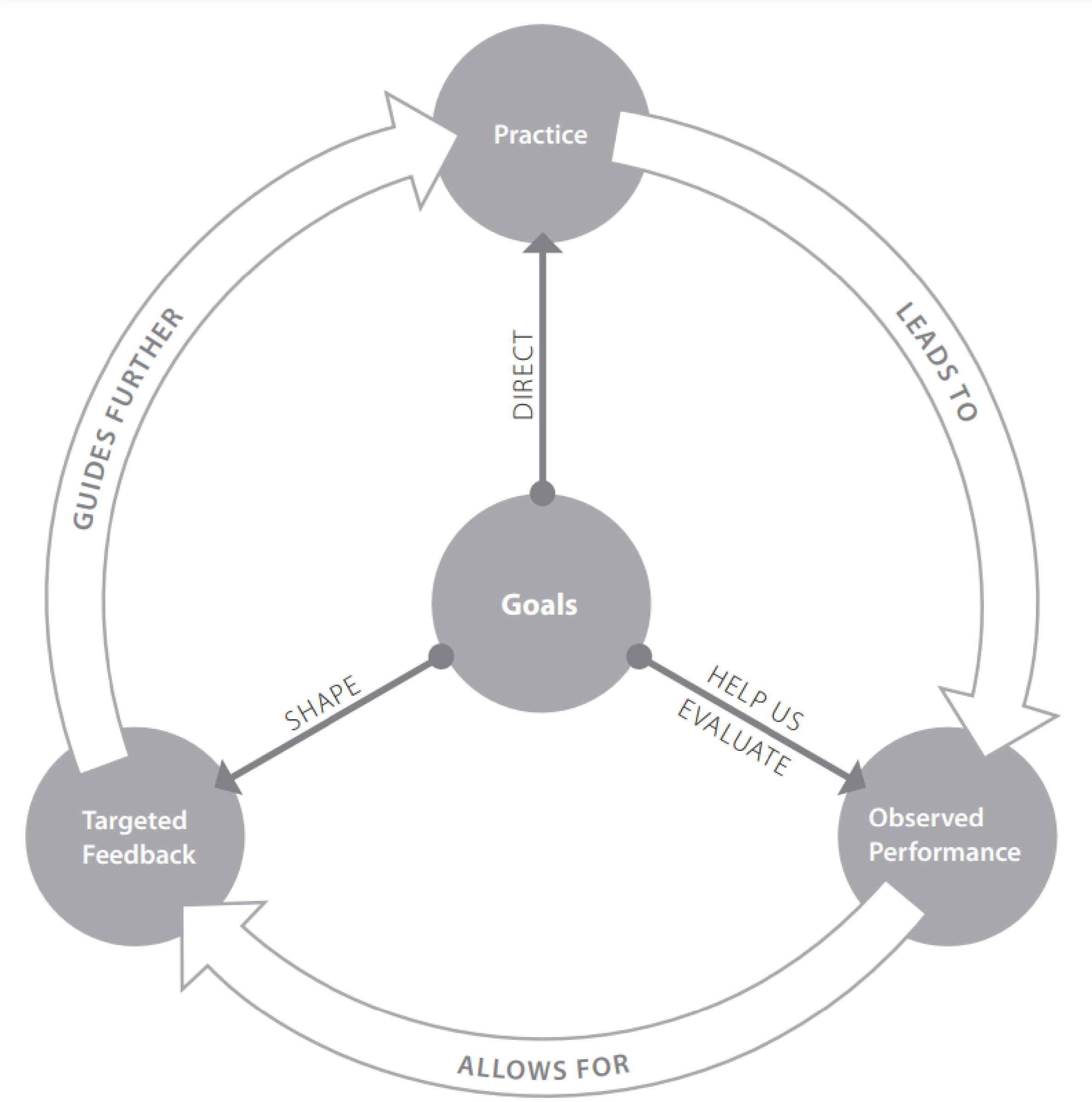


Figure 5.10.: A continuous cycle of practice and feedback. Retrieved from Ambrose et al. [Amb+10]

Essentially, the main purpose of practice is to produce an observable result that can be used to provide targeted feedback, and the feedback can then be used to guide further practice. For each aspect of this cycle to be successful, it must be integrated into a larger context of learning objectives.

In this sense, effective learning requires the establishment of a dynamic exchange of information between the learner and the educational system. To optimize this process, it is necessary to incorporate multiple regular inputs to provide feedback and enhance the learning experience [Ghe09]. Therefore, the effectiveness of feedback depends on its ability to facilitate learners' acquisition of targeted understanding and on the existence of a learning environment to which it is relevant. In other words, feedback must be contextualized within a learning environment to have a meaningful impact. This can be achieved when feedback leads to increased diligence, improves the ability to spot errors, or prompts the use of more effective methods [HT07]. Moreover, a crucial part of the learning process is providing feedback that encourages reflection [Van+20].

As part of gamification, continuous performance feedback can be received throughout the experience, stimulating validated behavior change components such as self-monitoring of the behavior outcome and self-monitoring of the behavior itself [Cug13]. Feedback mechanisms are designed to elicit real-time responses to specific actions or behaviors as a function of current status or progress. In the context of gamification, various strategies can be employed to provide feedback, as game elements typically provide feedback and can also be conceptualized as design principles that drive the interaction between mechanics and players [Ber19].

Providing feedback throughout the experience can be seen as an important element through which gamification can produce learning effects and retain its users. An individual's performance may also be positively affected by feedback, which may be provided visually or auditorily [Bur12]. A specific example of this is the use of real-time visual icons as a form of behavioral feedback that has been shown to improve performance [Pal+21; Dam+15]. Furthermore, as a method to address the lack of directional feedback in soft skills training, the use of virtual audiences has proven effective in improving performance [Pal+21]. According to Chollet et al. [Cho+15], the inclusion of virtual interactive audiences in training can lead to a marked increase in perceived attention and a general improvement, especially in the area of public speaking. These results suggest that the virtual audience can be a useful tool to improve the effectiveness of traditional feedback methods [Tan+16].

The optimal time to give feedback to learners has often been discussed. Some studies suggest that immediate feedback is most effective, while other studies suggest that delayed feedback may be more beneficial because it requires more cognitive processing [Van+20].

To facilitate engagement, clear goals and feedback are essential in a gamified system or environment [Nah+19], and combining real-time feedback with post-session feedback, especially when powered by digital feedback technology, has been shown to drive positive behavioral change through the promotion of self-awareness and self-regulation of unwanted behavior [XCD16].

In games and gamified applications, conformational feedback is commonly used to support the learning process. This type of feedback indicates whether a response, activity, or action is correct, incorrect, or somewhere in between. In addition to providing learners with immediate feedback on whether their actions are correct, this feedback mechanism does not provide additional guidance on how to correct any mistakes they may have made [Ber19; Kap13; Kap14; Pal+21; WH12; ZC11]. In short, a potential benefit of using cognitive feedback in a gamified system is the ability of the user to learn the rules of the game through direct experience rather than learning them explicitly. In addition, the system's immediate feedback can serve as an intervention to disrupt established behavior patterns and facilitate behavior change[Ber19].

In summary, to maximize the effectiveness of feedback, it must be aligned with the targeted competencies, delivered in a timely and consistent manner, and linked to opportunities for further practice. This ensures that learners can use the feedback provided to facilitate learning and development [HT07].

5.3.2. Technology Acceptance Model

The TAM has attracted significant attention in the information systems community as a means of understanding and predicting user acceptance of technology. Various models have been proposed for this purpose in the past two decades, but TAM has emerged as the most widespread and well-established [Chu09]. The development of TAM can be traced back to research by Davis [Dav85]. According to the idea espoused in his doctoral thesis, which was based on the theory of reasoned action and further research by Fishbein and Ajzen [FA77], it is possible to comprehend and anticipate how a system will be used by examining the user's motivations. The user's reasons for using the system can be shaped by various external factors, including the characteristics and capabilities of the system itself [Chu09; Dav85] (see Fig. 5.11).

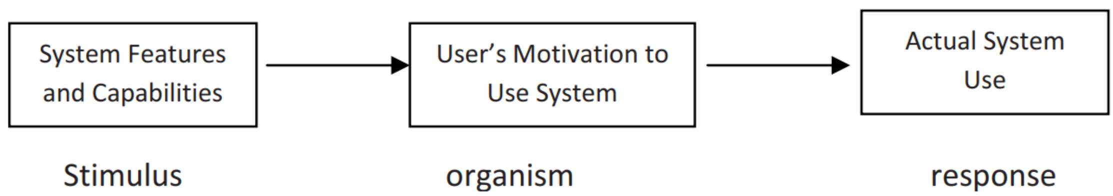


Figure 5.11.: Technology acceptance: the conceptual model. Retrieved from Chuttur [Chu09]

According to Davis [Dav85], a user's acceptance or rejection of a system is influenced by their motivation, which in turn is determined by three factors:

- Their attitude towards using the system
- Their perceived ease of use of the system
- Their perceived usefulness of the system

Davis et al. [DBW89] proposed an extension of the TAM that includes behavioral intention as a separate variable directly influenced by the perceived usefulness of a system. Therefore, behavioral intention is included in this model because it is possible for a person to have a strong intention to use a system that they find useful, even if they don't have a positive attitude toward it. The findings of their research showed that the perceived usefulness and ease of use of a technology had a direct impact on the person's behavioral intention to use it. As a result, the construct of attitude in the TAM was no longer necessary [VD96]. The final version of the TAM included only the behavioral intention construct and excluded the attitude construct (see Fig. 5.12).

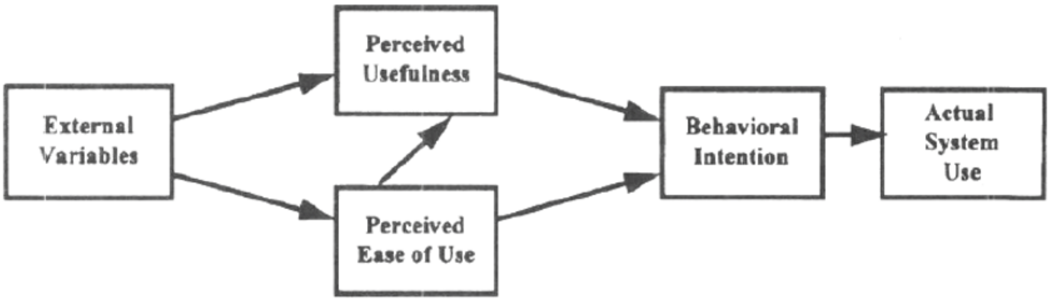


Figure 5.12.: The technology acceptance model. Retrieved from Palmas et al. [Pal+21]

In order to determine whether a technology will be accepted, it is important to consider the mechanisms that shape the user experience. It is important to realize that the effectiveness of a learning application is greatly influenced by how engaged the learner is. Hence, the properties that make video games attractive have been studied extensively, leading to the conclusion that integrating gamification into learning applications seems to be an effective approach to engage people [Pal+21].

5.3.3. Methods and Study Design

In this study, the VR-ST was redesigned with and without gamified direct feedback elements to investigate the impact of direct feedback on VR-ST. The direct feedback version includes a visual interface that provides gamified feedback. In contrast, the version without direct feedback relies on participants' analysis of the body language of the characters in the audience to determine the appropriateness of their performance [21]. Throughout this investigation, the TAM, which has been validated in previous studies, was used.

As part of this research to gain insight into the acceptance of direct feedback, two other constructs in addition to TAM were considered. Within the context of VR training, it is necessary to evaluate the potential benefits of gamification in terms of increasing intrinsic motivation and the risks of sensory overload. As stated by Davis [Dav85] and Thompson et al. [THH91], numerous scientific scales are available to measure intrinsic motivation and complexity [Pal+21].

By incorporating gamification elements into feedback mechanisms, strong intrinsic motivation from users was expected, leading to a positive perception of the product's usefulness and ease of use, as well as the intention to continue using it in the future. However, it is also possible that the added complexity introduced by direct feedback could diminish from the perception of ease of use. Therefore, it should be investigated whether the hypothetical

[21] It was named "simulation-based feedback".

benefits of direct feedback, including higher intrinsic motivation and complexity, as well as positive ratings of direct feedback, can be confirmed by positive evaluations of all constructs in the technology acceptance model.

Accordingly, Hypothesis 1 is defined as follows:

- **H1** *Direct feedback shows higher technology acceptance than simulation-based feedback.*

As part of this study, the impact of public speaking anxiety and previous VR experience were assessed as potential factors influencing the acceptance of VR-ST. It was hypothesized that people who are afraid of public speaking may be more inclined to use VR-ST, potentially leading to a higher level of acceptance. Additionally, prior exposure to VR could result in a more regular use of VR-ST, leading to higher perceptions of its ease of use. Furthermore, a higher perception of ease of use has the potential to increase the perception of the usefulness of VR-ST technology and behavioral intention.

Therefore, Hypotheses 2 and 3 are as follows:

- **H2** *Participants with public speaking anxiety show higher acceptance of technology than participants without public speaking anxiety.*

- **H3** *Participants with prior VR experience show higher technology acceptance than participants without prior VR experience.*

5.3.4. Setup and Implementation

For this study, a setup inspired by previous research [22] consisting of an HTC VIVE Pro Head-Mounted Display, two VIVE hand controllers, and two external HTC foot trackers was used. Two variants of the VR-ST (see Fig. 5.13) were built using the Unity 3D game engine. This configuration allowed 6-DoF and used inverse kinematics [23]. Compared to a full motion-capture system, this tracking method appeared to reduce latency and task load [Pal+19a]. Therefore, given the objectives of the study, this design was appropriate.

The VR environment was modeled after a business meeting room and featured three virtual characters as members of the audience. The graphical style of the VR-ST has been designed and enhanced to be as realistic and lifelike as possible.

[22] "Acceptance and Effectiveness of a Virtual Reality Public Speaking Training" by Palmas et al. [Pal+19a]

[23] The inverse kinematics algorithm estimates the position of the limbs using a five-point system (head, hands and feet). Using this information, the algorithm can calculate the posture of the spine and rotational movement of the waist within a user's avatar.

Figure 5.13.: A comparison of the simulation-based feedback and direct feedback versions. Retrieved from Palmas et al. [Pal+21]

Participants can choose to embody either a male or female avatar in the virtual environment during the presentation. This allows them to personalize their virtual representation for the duration of the presentation (see Fig. 5.14).

Figure 5.14.: Female (left) and male (right) avatars in VR as seen by the participants. Retrieved from Palmas et al. [Pal+21]

The effectiveness of a presentation, and thus the degree of audience reaction to it, can be assessed in real time by evaluating the audience's body language The nonverbal cues of the virtual audience typically reflect behavior in similar real-world situations (see Fig. 5.15), such as maintaining and seeking eye contact and adopting attentive postures in the case of a positively received presentation. In contrast, a negative reception is shown by lack of eye contact and visible signs of boredom, such as lying and resting their heads on their hands.

Figure 5.15.: Example of an animation of a bored character in the audience. Retrieved from Palmas et al. [Pal+21]

The implementation of a direct feedback system allowed participants to assess their own presentation skills and performance in conjunction with audience feedback [24] (see Fig. 5.16). A visual indicator in the form of a diamond-shaped symbol was displayed above the head of each member of the audience to identify the degree of attention that each individual pays at any given moment during the presentation. The color of the diamond would change, fading from green (indicating high levels of attention) to orange (moderate attention) to red (low attention) based on the level of engagement (see Tab. 5.8).

Degree of Attention	Color
Great to Good	Green
Neutral	Orange
Not enough to bad	Red

Table 5.8.: Degree of attention: color coding. Own representation.

Figure 5.16.: Gamified direct feedback in a VR speech situation. Retrieved from Palmas et al. [Pal+21]

The feedback interface (see Fig. 5.17) was designed to give participants continuous direct

[24]Non-verbal cues.

feedback. The purpose of this interface was to convey information in a clear and concise manner, including a combination of easy-to-understand symbols and words, as well as flashing red icons to alert the speaker to real-time mistakes made while presenting.

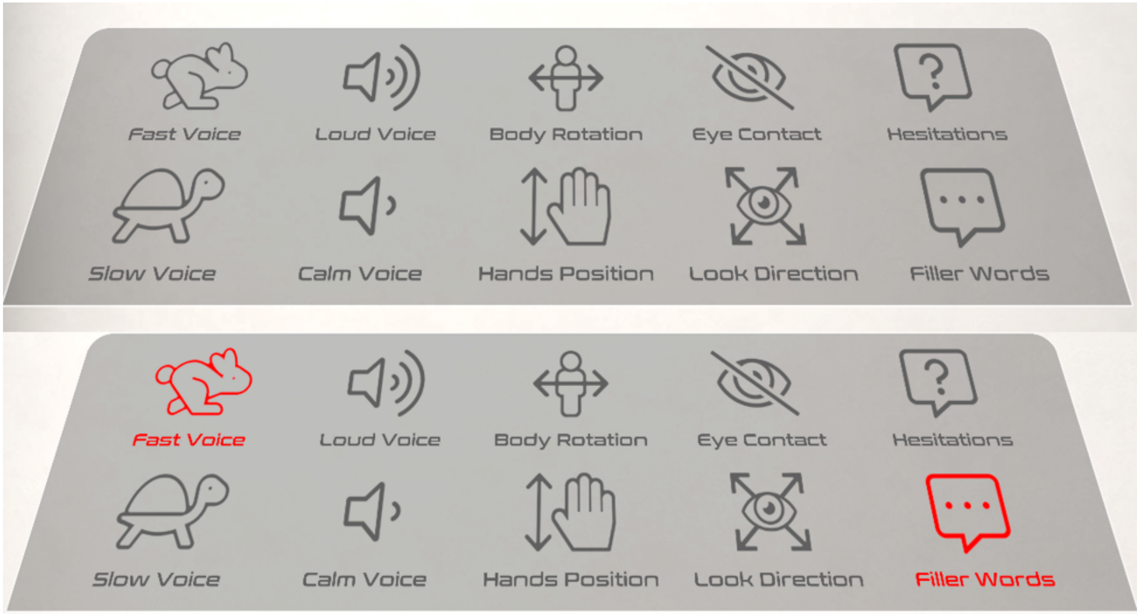


Figure 5.17.: A comparison of direct feedback interfaces, one showing the direct feedback interface (not active) and the other showing the direct feedback interface (active) using additional filler words and speaking at an accelerated pace (shown below). Retrieved from Palmas et al. [Pal+21]

These red icons allow the presenters to react instantly and adjust their behavior to improve their performance (see Fig. 5.16). When necessary behavioral adjustments are made successfully, participants receive positive feedback in the form of flashing green icons.

As shown in Fig. 5.17, the use of animal symbols, such as a rabbit and a turtle, serves to demonstrate the speed or sluggishness of verbal communication. The loudspeaker icon gives feedback on the volume of the voice, whether the voice is too loud or too soft, and suggests adjusting the volume accordingly. The depiction of a body and a hand symbolizes inappropriate postural habits, including excessive or rigid movements. The upper eye icon indicates lack of eye contact, while the lower eye icon indicates an incorrect line of sight. The inclusion of a question mark suggests the use of colloquial expressions as fillers in pauses in speech [25], while the representation of a speech bubble indicates the use of filler words.

In order not to disturb the flow of speech during the presentation, the symbols for speaking rate, hesitation, and filler words were displayed only when the speaker paused after a sentence. This choice was made because the constant display of the icons could have been distracting to the participants.

[25] E.g., “hem”, “hum”, or “hm”.

At the end of a virtual speech, a summary of the feedback was provided to present the information clearly and concisely. The goal was not to overwhelm the participants with too much information during their presentation. To facilitate this, a five-star point system was used for both versions of VR-ST.

Figure 5.18.: At the end of the speech, a summary of the awarded stars that reflect the quality of the performance was given. Retrieved from Palmas et al. [Pal+21]

The point system allows for an easy assessment of the speaker's performance and helps ensure that it is easy for the presenter to understand by providing feedback on the following areas of the speaker's performance in relation to the following metrics (see Fig. 5.18):

- Body language
- Eye contact
- Time management
- Audience attention
- Voice
- Overall score

The point system and audience feedback were based on automatically collected and measured VR-ST metrics (see Tab. 5.9). Eye contact, for example, was calculated as the ratio of time spent looking at the audience to the total time spent speaking. Values below 25%

were rated with 0 stars; values above 85% were rated with 5 stars. Intermediate values were evaluated using linear interpolation to calculate the score.

Metric	**Perfect Balancing**	**Tracked**
Audience Attention	100	Percentage (Eye Contact, Filler Words, Hands)
Words per Minute	100, 150	Words
Eye Contact	Audience	Audience, Laptop, Screen, Floor, Other
Position	Move Around in the Room	Body Position in the VR Room
Hand Position	Mid (TV Window)	Hands Mid, Low, High
Filler Words	None	Like, Uhm, Well, Stuff, Yeah, So
Confidence	100	Quality of the Pronunciation of the Spoken Words
Body Orientation	Body Facing the Audience	Body Facing Forward, Side, Back
Look	Looking at Eye Level of the Audience	Looking Forward, Up, Down
Time	Elapsed Time = Estimated Time = max. Time	Self-Estimation of the Presentation's Time and the Actual Presentation Time
Speech Recognition	Accurate Transcript with No Filler Words	Red Words are Bad Filler Words

Table 5.9.: Metrics used to generate feedback for each participant and determine the audience's adaptive attention. Retrieved from Palmas et al. [Pal+21]

5.3.5. Sample

The study involved a sample of 200 undergraduate students who were evenly divided into two groups of 100 participants each [26]. As part of the study, one group used VR-ST with direct feedback, and the other used VR-ST with simulation-based feedback. The goal of this design was to allow a fair comparison of the two VR-ST versions. The main characteristics of the participants in the two groups are summarized in Table 5.9.

[26] An equal distribution of participants with n = 100 per condition was ensured.

		Direct Feedback	Simulation
Sex	Female	36%	30.5%
	Male	14%	19.5%
Age	19-29	47%	47%
	30-40	2.5%	2%
	> 40	0.5%	1%
Console	Never	25%	25%
	Rarely	15.5%	11.5%
	Frequently	4.5%	8%
	Regularly	5%	5.5%
VR	Experienced	20%	13.5%
	Inexperienced	30%	36.5%
Training	Experienced	22%	19.5%
	Inexperienced	28%	30.5%
Public Speaking Anxiety	Yes	24.5%	26%
	No	25.5%	24%

Table 5.10.: Characteristics and distributions of the sample. Retrieved from Palmas et al. [Pal+21]

5.3.6. Questionnaires

This study examined the technology acceptance of VR-ST using a variety of measures, including the TAM developed by Davis et al. [DBW89], scales for measuring intrinsic motivation by Davis et al. [DBW92] and complexity by Thompson et al. [THH91]. These measures consisted of multiple items, with the factors of perceived usefulness, perceived ease of use, behavioral intention, and intrinsic motivation each comprising three items. The complexity was assessed using four items and it is important to note that the scaling of the complexity measure was reversed in polarity, such that higher scores on the complexity measure corresponded with lower perceived complexity.

To collect data, questionnaires were used to ask participants to rate their responses on a seven-point Likert scale. This scale was chosen to measure the extent to which participants agreed or disagreed with the statements given. Scores on this scale ranged from 1, meaning that the statement is "totally not applicable", to 7, meaning that it is "totally applicable".

Public speaking anxiety was measured using the personal report of confidence as a speaker (PRCS) scale [27], which consists of 30 nominally scaled items intended to reflect common symptoms of anxiety that people may experience prior to speaking in public. Participants were asked to answer these items in a binary "yes" or "no" answer format. Those who endorsed at least 50% of the items as "yes" were classified as having public speaking anxiety. In contrast, those who endorsed fewer values were classified as not having anxiety related to public speaking. In addition to this measure, the study also included a question about the participants' prior experience with VR, which was coded as a binary "yes" or "no" answer.

[27] PRCS is commonly used as a measure in the treatment and research literature to determine whether people are afraid of public speaking.

For those who reported having VR experience, there was an open-ended question asking for further details about their VR expertise.

5.3.7. Study Design

For the purposes of this study, two sets of questions were administered to collect data. The first questionnaire was completed prior to the VR-ST session and included items related to participant demographics, VR experience, and anxiety about public speaking as assessed using the PRCS. The second questionnaire was given after the VR intervention and included questions from the TAM and items that measure intrinsic motivation and complexity. Both the direct feedback and simulation-based groups of speech training participants received the same questionnaire. Furthermore, to ensure the validity of the results, all participants followed the same procedures and used the same settings of the VR-ST system during the study. Each participant selected a topic for the VR-ST session and prepared a digital presentation in advance.

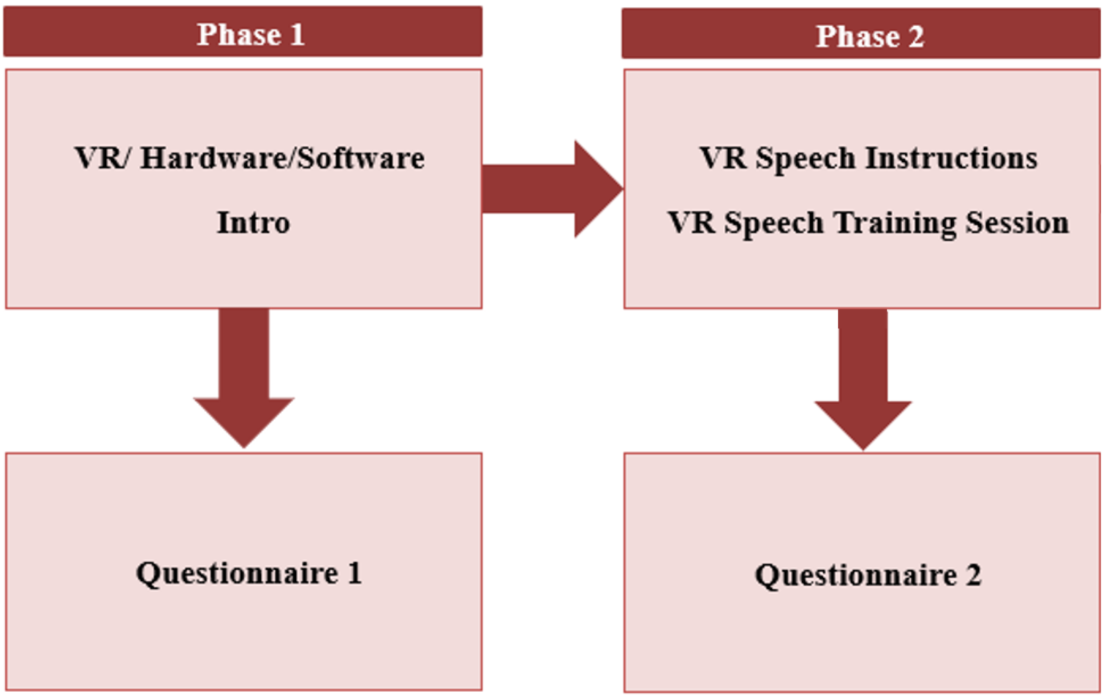


Figure 5.19.: The two phases of the study. Own representation.

It is possible to divide the study procedure into two phases (see Fig. 5.19), as follows:

- **Phase 1:** Participants were given an overview of how the VR-ST works and the underlying structure of its system. Then, they completed the first questionnaire.
- **Phase 2:** Participants received instructions and the opportunity to choose an avatar.

Then, they were asked to rate the difficulty of each slide [28] to improve time management and balance audience attention. The VR-ST session was held in a virtual office environment where the participants gave a presentation in front of an audience and a laptop with the presentation open [29]. The presentation time was limited to five minutes and a scale-based point system provided feedback on body language, eye contact, time management, audience attention, voice, and an overall score based on data collected during VR-ST session.

5.3.8. Results

Regarding Hypothesis 1, a MANOVA [30] was conducted to determine whether VR-ST with direct feedback [31] results in higher technology acceptance compared with the simulation-based version [32]. The results presented in Table 5.11 indicate that the direct feedback version had statistically significantly higher mean scores on all subscales of technology acceptance.

Dependent Variable	Condition	EMM	SE
Perceived Ease of Use	Direct Feedback	6.397	.091
	Simulation	5.480	.091
Perceived Usefulness	Direct Feedback	5.780	.097
	Simulation	4.830	.097
Behavioral Intention	Direct Feedback	6.240	.096
	Simulation	5.213	.096
Intrinsic Motivation	Direct Feedback	6.463	.085
	Simulation	5.790	.085
Complexity	Direct Feedback	5.983	.089
	Simulation	5.465	.089

Table 5.11.: H1: Estimated marginal means (EMM) and standard errors (SE). Retrieved from Palmas et al. [Pal+21]

The results regarding the effect of the system design showed a statistically significant impact, as indicated by an F ratio of $F(5,194) = 16.414$ ($p < 0.001$) and a Pillai's Trace of 0.297. Detailed results for each univariate test are presented in Table 5.12, and the correlations

[28] Difficulty levels of low, medium, and high corresponded to the time that participants were likely to spend on each slide.

[29] Once participants clicked the go-to-office button, they were transported to a virtual office environment. Here, they stood in front of the audience and presented their presentation on an open laptop. The time counter was activated when the start button was clicked. The presentation was then displayed on the laptop and on the screen behind the participant in the virtual environment. Each participant had a time limit of five minutes to complete the VR-ST session, excluding the setup phase. Clicking the stop button ended the speech session.

[30] For all three hypotheses, all assumptions for MANOVA were fulfilled.

[31] $n = 100$.

[32] $n = 100$.

between constructs are shown in Appendix (see A.2).

Dependent Variable	F	df	η_{p^2}
Perceived Ease of Use	50.450	1	.203*
Perceived Usefulness	47.598	1	.194*
Behavioral Intention	57.363	1	.225*
Intrinsic Motivation	31.191	1	.136*
Complexity	16.750	1	.078*

(*p < .001)

Table 5.12.: Results of the MANOVA for H1. Retrieved from Palmas et al. [Pal+21]

Hypothesis 2 proposed that individuals who suffer from public speaking anxiety [33] would demonstrate greater acceptance of technology than those without such anxiety [34]. Using a two-way MANOVA, the effects of system design and public speaking anxiety on sub-scales of technology acceptance were investigated.

The results presented in Table 5.13 support the finding that demonstrates that people with public speaking anxiety had significantly lower technology acceptance across all subscales. A statistical analysis (F ratio of F [5,192] = 9.187 [$p < 0.001$] and a Pillai's trace of 0.193) support this result.

Dependent Variable	Group	EMM	SE
Perceived Ease of Use	No Public Speaking Anxiety	6.296	.085
	Public Speaking Anxiety	5.593	.084
Perceived Usefulness	No Public Speaking Anxiety	5.484	.097
	Public Speaking Anxiety	5.129	.096
Behavioral Intention	No Public Speaking Anxiety	5.955	.093
	Public Speaking Anxiety	5.497	.093
Intrinsic Motivation	No Public Speaking Anxiety	6.393	.082
	Public Speaking Anxiety	5.870	.081
Complexity	No Public Speaking Anxiety	5.981	.086
	Public Speaking Anxiety	5.469	.086

Table 5.13.: H2: Estimated marginal means (EMM) and standard errors (SE). Retrieved from Palmas et al. [Pal+21]

Table 5.14 shows the detailed results of the univariate test for each sub-scale.

[33] n = 101.
[34] n = 99.

Dependent Variable	F	df	η_{p^2}
Perceived Ease of Use	34.792	1	.151*
Perceived Usefulness	6.786	1	.033***
Behavioral Intention	12.087	1	.058**
Intrinsic Motivation	20.700	1	.096*
Complexity	17.713	1	.083*

(*p < .001, **p < .01, ***p < .05)

Table 5.14.: Results of the MANOVA for H2. Retrieved from Palmas et al. [Pal+21]

Hypothesis 3 stated that people who had previously experienced VR technology would show higher technology acceptance than those who had not. The effect of VR experience and system design on technology acceptance sub-scales was examined using a two-way MANOVA. According to the data analyzed, no statistical significance was found in the interaction effect between the system design and the VR experience or the main effect of the VR experience.

5.3.9. Discussion and Limitations

The purpose of this study was to determine whether a VR-ST with direct feedback is better accepted and received than a simulation-based VR-ST. To answer this question, an experiment between subjects was conducted with 200 participants. After completing a VR-ST session, participants completed a questionnaire that assessed their acceptance of technology using the TAM. In addition, intrinsic motivation and complexity were assessed.

Hypothesis 1 predicted that participants who trained with the VR-ST with direct feedback would demonstrate higher acceptance of technology, higher intrinsic motivation, and lower complexity compared to participants in the simulation-based version. Based on the findings, this hypothesis is fully supported. According to MANOVA, the group that used the VR-ST with direct feedback showed significantly higher ratings in terms of perceived usefulness, perceived ease of use, behavioral intent, intrinsic motivation, and complexity. The results are consistent with the prediction that the direct feedback VR-ST would be more effective in terms of technology acceptance and learning outcomes due to the inclusion of gamified elements and direct feedback. Gamified approaches, such as instant feedback icons and audience engagement indicators, may have contributed to improved attention and retention in the VR-ST with direct feedback compared to the simulation-based version, which did not have these elements. This is consistent with previous research on the positive effects of gamification and direct feedback on technology adoption and learning.

In the direct feedback version of VR-ST, the high perceived usefulness rating may be due to the use of icons that provide instant feedback regarding the quality of public speaking. A further contributing factor may have been the use of attention markers above the audience's heads to indicate engagement, which is a more intuitive way of displaying audience engagement compared to the simulation-based version. According to the TAM model, high ratings of perceived usefulness and perceived ease of use can reduce perceived barriers to using a new technology, resulting in a higher intention to use it.

The higher rated intrinsic motivation in the VR-ST version with direct feedback than in the simulation-based feedback can be explained by the connection between intrinsic motivation and gamification elements, which are present as direct feedback elements comparable to gamification elements. Furthermore, the direct feedback version was perceived as less complex than the simulation-based feedback version, as shown by the reverse-coded responses to the complexity questions. These results support the importance of considering both intrinsic motivation and complexity when evaluating different versions of VR-ST in terms of users' technology acceptance. The direct feedback version was designed to provide simple and easy-to-understand feedback through elements such as audience engagement indicators and speaking feedback, which may have contributed to its reduced perceived complexity.

As discussed by Palmas et al. [Pal+21], it is worth noting that the effectiveness of feedback depends on its acceptance, which is influenced by the credibility of the feedback source. Therefore, the credibility of the feedback source is a key factor in determining its acceptability, and as the technology acceptance of the VR-ST increases, the acceptance of the feedback is also likely to increase, suggesting that improvements in technology acceptance can improve the overall effectiveness of this training method. However, more research is needed to fully understand the influence of feedback acceptance on the effectiveness of VR-ST. Additionally, individuals often trust their own judgments much more than the feedback they receive from others during a training experience. This can be attributed to psychological factors such as confirmation bias and self-protection, leading to an overestimation of performance.

In this context, it is important to note that the lack of prior VR experience could affect a person's perception of their own abilities in a VR training environment. This potentially hinders their acceptance of feedback and ultimately reduces the effectiveness of the learning experience. In other words, prior exposure to VR could affect the ability of a person to absorb and apply new information learned during a VR training session. Overall, this is an important consideration when designing and implementing VR training applications.

In this study, participants were tested under standardized conditions, and the level of difficulty was not adjusted to their performance. Although game elements often aim to optimize the user's experience by tailoring their challenge to the user's skill level, this approach was not used in the present study to ensure the validity of the measurement. However, due to the lack of difficulty adjustment, some participants may have performed poorly or over-performed, which may have negatively impacted the intrinsic motivation and complexity measurements.

To address these potential limitations in future research, it may be beneficial to classify presentation performance based on of skill assessments before participants use the VR-ST. For example, a previous short speech could serve as a baseline measure of the user's skill level, allowing for more tailored difficulty adjustments in the VR training. This approach would help ensure that all participants achieve an optimal learning experience, as the perfect balance between challenge and skillset influences how focused a learner is (see Flow Theory in Section 2.4.6). By considering these issues and implementing strategies such as skill assessments and difficulty adjustments, it should be possible to improve the validity of future measurements and better understand the impact of VR-ST on intrinsic motivation and complexity. This will help to expand the understanding of the effectiveness of VR-ST, but also of VR training as an educational learning tool.

A possible direction for future research using VR-ST is to investigate how to achieve the optimal level of challenge for anxious participants. Additionally, the use of difficulty levels could be combined with dynamic difficulty adjustment in VR-ST to provide an optimal level of challenge for anxious participants. This potential solution could provide real-time adjustment of the challenge level based on user performance. Furthermore, by combining VR simulations with biometric measurements, such as electrodermal activity, it would be possible to examine the stress response in individuals with VR-ST. Researchers can study how the anxiety of public speaking translates to VR environments in real life. As a result, based on this information, VR simulations could be dynamically adjusted in real-time to account for participants' stress levels. Being able to make such adjustments can effectively and accurately alleviate stress for people who are afraid of public speaking and thus improve the overall VR experience. However, it is important to note that the effectiveness of dynamic difficulty adjustment in VR-ST has yet to be rigorously examined and should be the focus of future research.

The results did not support Hypothesis 2 that participants with public speaking anxiety were more likely to accept VR-ST. The MANOVA results showed that, in all dimensions of the TAM, the participants with public speaking anxiety actually showed significantly lower technology acceptance as well as lower intrinsic motivation and higher perceived complexity.

A possible explanation for this unexpected result could be the discomfort or anxiety that these participants experienced when using the VR-ST. It is known that people with high levels of anxiety tend to perceive new or unfamiliar situations negatively, which can lead to a lower acceptance of VR-ST. Additionally, the immersive nature of VR may have increased feelings of discomfort or anxiety in these participants, resulting in a lower overall acceptance of the intervention.

Because the VR-ST was implemented with an emphasis on high graphic fidelity and a believable presentation scenario, it is possible that this level of realism evoked feelings of fear or discomfort in these participants. By creating a realistic and potentially fear-inducing public speaking scenario, the VR-ST may have reduced some of its potential benefits for participants with high levels of public speaking anxiety. These individuals may have found the VR-ST experience too stressful or overwhelming, resulting in a lower acceptance of technology. This finding should also re-emphasize the importance of considering learners' experience levels and comfort when designing and implementing educational technologies. Additionally, it may be necessary to incorporate additional gamified supported mechanisms or adjust the difficulty level of VR-ST to better meet the needs of individuals with public speaking anxiety.

To examine Hypothesis 3, an attempt was made to identify any correlation between VR experience and acceptance of the VR-ST. However, no significant correlation was observed.

There are several possible explanations for this result. An overly simplistic measurement method may have been used to evaluate the VR experience. Because it used only one item to rate the VR experience, it may not have provided a reliable measure of this construct. Measurements of a single item are often prone to poor statistical validity, which may have impacted the results of this study. Furthermore, participants were divided into two levels of VR experience based on a single question and optional additional information. This lack of detail may have contributed to the failure to establish a significant relationship between VR experience and VR-ST acceptance. To better understand the relationship between VR experience and acceptance of VR technology, further research should use broader measures of VR experience.

5.4. Summary

Previous research on the use of VR for public speaking training has focused largely on the effectiveness of VR in reducing anxiety and the effects of virtual audience reactions on participants. However, these studies were often statistically underpowered, and the incorporation of gamification principles into VR speaker training has been explored only to a limited extent.

This study has provided evidence of the effectiveness of the TAM for assessing the acceptance of immersive VR applications. Taking into account the intrinsic motivation and complexity in this research design, a deeper understanding of aspects of the VR experience that are not directly addressed by the TAM was also gained. Furthermore, this study involved the implementation and comparison of two versions of VR-ST, and a large-scale experimental study35 was conducted to verify the results.

The results showed that the VR-ST with direct feedback was better accepted than the VR-ST with simulation-based feedback. These results suggest that integrating direct feedback elements into VR training could improve participants' public speaking skills. It is imperative for developers of VR training applications to consider how they make information available to users in order to optimize the learning experience.

This study highlights the value of integrating direct feedback elements into VR simulations for public speaking and communication training. More research is needed to examine the impact of VR experiences and prior fears of public speaking on the effectiveness of these training applications. To optimize learning outcomes, it is recommended that developers of commercial training tools carefully consider the design of their feedback systems.

In summary, this study not only made a contribution to VR research but also showed that direct feedback is a well-accepted and innovative method for VR training. Given these results, more research is needed to explore the acceptance and additional impact of gamified VR training and to highlight its usefulness in the educational field.

6. Adverlearning

This chapter provides an overview of the definition and explanation of adverlearning as outlined in the study published by Palmas and Klinker [PK21]. In the following sections, part of the text has been excerpted from the cited publication and adapted. This study presents and explores the novel concept of adverlearning and its potential impact on the field of education and learning. In addition, it examines the potential benefits and applications of adverlearning and discusses the challenges and considerations involved in its implementation.

6.1. Background

As discussed in detail in Section 2.6, video games have become one of the main achievements of the entertainment industry due to their growing market and the opportunity to generate new business. Furthermore, researchers and marketers have recognized the success of video games and their underlying mechanisms and have tried to apply these principles to other areas.

In recent years, the integration of marketing strategies into digital content, including video games, has emerged as a method of increasing brand recognition and awareness among consumers. These strategies, which often go beyond simple product placement, offer advertisers multiple opportunities to design and place advertising content within games. In this way, brand values and product information can be passed on to the target group [PK21].

6.2. Defining Adverlearning

Due to resistance to change and dependence on outdated training methods, the education sector struggles to adapt to recent societal changes and future needs. This underscores the need for innovation in this sector and shows that, rather than relying on traditional methods, a proactive approach is needed to address the need for change [PK21].

Learning through video games can be seen as an innovation in the field of learning, and the principles of video game development can be used to create engaging learning experiences that can help individuals grow and develop. In addition, the most effective way to use video games as a learning tool is to prioritize engagement and fun while also teaching valuable skills and information.

Research has shown the benefits of serious video games or video games intended for educational or training purposes. According to Palmas and Klinker [PK21], serious games can be limited by not offering the same fun factor as commercial games when used in real world contexts rather than for research purposes. Because commercial video games are often designed for entertainment purposes, players are more likely to perceive them as such than serious games. In addition, they also tend to have more resources and development time. As a result, serious games must provide an engaging and enjoyable experience comparable to that of popular commercial video games to effectively achieve their intended educational goals [PK21].

It is possible to study the properties and effectiveness of fun and engaging video games to adapt specific techniques and approaches, as well as to incorporate innovative teaching methods, with the aim of improving the learning experience for younger generations. By combining in-game advertising (see Section 2.6.2) and educational content in video games, games can deliver learning materials in fun and engaging ways that can potentially enhance learning and be used to create new approaches to learning.

Based on the analysis of different types of in-game advertising in section 2.6.2, the following is the definition of adverlearning is:

> *"The repurposing of in-game advertising's methods and strategies for conveying learning content and achieving educational goals by applying them to video games."* [PK21]

According to Palmas and Klinker [PK21], this definition requires some clarification.

The use of in-game advertising has been proven to establish a connection between the viewer and their purchasing behavior toward a product from the advertised company. Therefore, the inclusion of educational content in these advertisements has the potential to motivate learners to seek further knowledge on a given topic in a playful, fun, and interactive environment. Moreover, the user could perceive the learning content in a similar way to advertising, as adverlearning uses strategies previously developed for in-game advertising.

This way of conveying information differs in design and purpose from serious games, which are specifically designed to convey learning material. Adverlearning can be viewed as a learning approach that integrates instructional and learning content into video games while capitalizing on their inherently engaging and fun nature. The learning content is made available indirectly through the use of strategies developed for in-game advertising. One of the key potential benefits of adverlearning is its flexibility, as learning content can be incorporated into any type of video game, both new and existing, regardless of genre or platform. Additionally, the integration of adverlearning into existing video games as a mechanism for delivering learning material avoids the need to change the game's storyline, mechanics, or design principles. Another advantage of adverlearning is that it allows learning content to be delivered to players in an unobtrusive and engaging manner, potentially leading to better retention and understanding of the material.

6.3. Discussion and Limitations

To facilitate learning while creating a fun gaming experience, adverlearning offers several potential solutions to this challenge. One solution could be to implement it as an additional layer in existing commercial games to leverage their already established entertainment value. Another potential solution is to incorporate adverlearning into the design and development of a new video game to seamlessly integrate learning content into the world and mechanics of the game. Although the potential of advertising as a valuable learning tool is evident, empirical evidence of its effectiveness is currently lacking. Detailed research is required to determine how to use adverlearning most effectively and assess its impact on learning outcomes.

An issue that should be addressed is that people who actively play certain types of video games may experience reduced learning effectiveness from adverlearning, especially when a game requires high levels of attention and mental ability. The reason for this is that a significant amount of cognitive resources may be used to play the video game, leaving a limited capacity to process and store the advertised learning information. In such a case, adverlearning might facilitate the retention of previously acquired knowledge or concepts rather than the acquisition of new knowledge.

However, streaming video games may offer a way to mitigate this impact. Stream viewers may have more of their cognitive resources and attention spans available to process and retain promoted information because they are not actively playing the game. Unlike traditional methods, this approach can be perceived as less intrusive and to facilitate learning through repetition and habituation. With the potential to broaden the target audience of adverlearning to passive gamers who prefer to watch video games rather than actively participate in them, this approach could present an opportunity to make this form of learning more attractive. Additional research is needed to fully understand the effect of adverlearning on active and passive gamers and to optimize the delivery of advertised information in the context of streaming video games.

Another approach that needs to be explored in research is the use of adverlearning in XR in the context of gaming, which allows players to be fully immersed in interactive environments, potentially leading to greater enjoyment, engagement, and more effective learning.

Although the use of immersive technologies in adverlearning may hold promise, more research is needed to fully understand their impact on the perception of learning content. This includes studies that examine how different XR technologies can impact learning outcomes and how best to design adverlearning experiences that take advantage of the immersive nature of these technologies. Overall, the potential of adverlearning to facilitate learning transfer through the use of immersive technologies is an exciting area for future research, and by better understanding how these technologies impact the perception of learning content, it is possible to optimize adverlearning and promote more effective learning.

6.4. Summary

The current education system appears to lack the capacity to meet the needs and desires of younger generations and the future learning needs of society. As a solution to this problem, a new concept called adverlearning is proposed and offers the possibility of incorporating educational content into video games through in-game advertising. This approach uses the engaging and fun nature of gaming to support the learning process. Future studies should investigate whether this new approach to learning is feasible to create a more effective and engaging learning experience for learners of younger generations and should ultimately work toward the goal of empowering people with lifelong learning and realization of their potential.

7. Discussion and Future Work

This dissertation investigated the effect of gamification on corporate XR training using an exploratory approach. Despite the increasing use of gamification in different training contexts, little is known about its potential advantages and disadvantages in the context of corporate XR training. To help fill this gap in the literature, the main research question was formulated as follows:

- *Does gamification have the potential to positively impact corporate extended reality training?*

The theoretical foundations of this dissertation were drawn from relevant literature on the core topics. Based on these foundations, several hypotheses were formulated and tested.

Overall, the theoretical basis and results of the examined studies indicate that gamification can have positive effects in the context of corporate XR training. However, more research is needed to confirm these findings and examine the mechanisms through which gamification can affect learning in this context. By addressing limitations and conducting further research on this topic, it may be possible to provide a more definitive answer to the main research question and make more robust claims about the impact of gamification on corporate XR training.

Given the exploratory nature of this dissertation, a thorough analysis of the results follows to ensure a full understanding and interpretation of these findings.

Incorporating XR technologies into corporate training has the potential to revolutionize the way companies train their employees. However, there has been a lack of consensus on the definition and understanding of XR, leading to confusion among academics and professionals in various fields [Rau+22b], not just in corporate training. Establishing a clear and consistent definition of XR in the context of training is essential to address these issues.

XR training is defined as follows (see Section 3.4):

> *"xR training is a purposely designed, immersive learning experience, which takes advantage of the appropriate technologies. These technologies engage and support employees when acquiring the knowledge and skills needed to drive the behaviors that impact specific business outcomes, which are aligned with organizational goals."* [PK20]

In this definition, the concept of "purposely designed" instructional methodology emphasizes the importance of carefully selecting and implementing techniques and strategies with the aim of optimizing learning outcomes. This approach recognizes that the mere transmission of information is not sufficient for effective learning, and the active participation and motivation of learners are crucial to facilitate the acquisition of knowledge and skills. Gamification has been proposed as a technique to be used as part of a purpose-designed instructional methodology, as its elements, all of which are key components that can be used in educational contexts, have the potential to effectively increase motivation and engagement.

In the context of this dissertation (see Section 2.5.3), a refined definition of gamification is proposed as follows:

> *"The process of making something a game, or game-like, with the goal of providing guidance and feedback through game mechanics, dynamics and aesthetics to achieve specific goals and objectives. It supports behavioral changes by motivating specific proactive and reactive behaviors within the gamified situation or application and positively impacting real-world situations."*

In summary, the proper use of gamification as part of an effective instructional methodology can potentially improve the effectiveness of the learning experience and facilitate the achievement of desired learning outcomes.

To investigate the potential benefits of gamification in hard skill training in VR, a study was designed using a VR assembly task and compared the performance and learning outcomes of a gamified versus a non-gamified version of the training (see Chapter 4). As reported by Ulmer et al. [Ulm+20], this approach has a high degree of novelty:

> *"Only Palmas et al. is comparing VR and Gamification manufacturing applications by analyzing the efficiency of a gamified and non-gamified assembly training tasks."* [Ulm+20]

The central hypothesis was that, by integrating game elements into VR training, training effectiveness would be improved, as stated by the following subhypotheses:

- **H1** *The experimental group* [1] *will exhibit a different distribution of error counts than the control group.*

- **H2** *The experimental group will exhibit a different distribution of error criticalness than the control group.*

Classifying errors according to their criticality is a common practice in various fields, including business, as it allows companies to prioritize correcting and avoiding errors. This is important because failures can have a number of consequences for a business, such as wasted time, wasted resources, and lost profits. Therefore, it is important to first address the most pressing issues. Errors can be classified in a range between critical and non-critical, depending on their potential impact on an organization's goals. Additionally, categorizing

[1] This group used the gamified version.

errors by criticality could make it easier to track and analyze performance over time in VR training.

Consistently collecting and analyzing data on the frequency and impact of errors and mistakes made in VR training could help companies identify patterns and trends, and implement targeted interventions to prevent future failures by improving training design and applying gamification approaches. This, in turn, could lead to improved efficiency, productivity, and profitability.

A sample of 50 participants with no prior drum kit assembly experience was randomly assigned to either the experimental group, which received the gamified training, or the control group, which received the non-gamified training. The study results showed a trend towards improved performance and fewer errors in the experimental group compared to the control group, although this difference was not statistically significant. However, these results do not allow definitive conclusions about the effectiveness of gamified training for this assembly task to be drawn; rather, they suggest the possibility of a positive effect.

A stronger trend in favor of the gamified version was found among a subset of participants who were new to VR technology. To further examine this result, additional tests were conducted, and the subgroup was expanded to include a total of 14 VR novice participants, who were randomly assigned to either the gamified or non-gamified condition.

As an additional indication of the potential benefit of gamification for this group of VR novices, two additional subhypotheses were formulated:

- **H3** *VR inexperienced users of the experimental group will exhibit a different distribution of error counts than the respective part of the control group.*
- **H4** *VR inexperienced users of the experimental group will exhibit a different distribution of error criticalness than the respective part of the control group*

In this context, gamification showed a statistically significant positive effect on performance and learning outcomes. In addition, it also influenced learning behavior and facilitated knowledge transfer.

In the results, the experimental group with the gamified VR training was observed to complete the assembly task almost 12.2% faster and made 30.2% fewer errors than the control group. The criticalness value was also 26.5% lower in the experimental group. This effect was particularly pronounced in participants with no prior VR experience, as they showed a 53.3% reduction in errors and a 48.1% decrease in the criticalness score in the gamified condition.

In this study, the use of a cymbal boom stand as a measure of assembly ability could be viewed as a limitation, as it may not fully capture the complexity of the task, and some participants may have used intuitive rather than learned solutions. This introduces the possibility of noise in the recorded data, which could raise concerns about the validity of the results and their generalizability to other contexts. In order to more accurately assess skills such as hand-eye coordination, multitasking, and memory performance, it may be necessary to use more complex and unusual objects as test subjects in future research. Additionally, a potential limitation of the study is the small sample size, which may have reduced the power to detect statistically significant differences between the two groups. Future research with larger sample sizes is needed to more robustly assess the effectiveness of gamified training for this type of hard skills training.

In summary, the results suggest that gamification has the potential to be used as a tool to improve the effectiveness of VR training, but more research is needed to confirm these results and understand their generalizability.

Given the limited use and adoption of VR for soft skills training and the challenges of measuring its effectiveness, the research on VR-ST is in an area of particular interest. The inclusion of the group of participants selected for this study, who were employees of a real organization and students of an MBA program for executives, is crucial to understanding how the findings can be reflected in company training and in the actual organizational setting.

Using VR-ST, data were collected using a Likert scale and open-ended questionnaires on participants' experiences and self-reported improvements were collected to examine acceptance, effectiveness, and potential of VR for soft skills training.

According to the self-evaluations of the participants, VR-ST proved to be beneficial in overcoming their fear of public speaking. Furthermore, a large majority [2] believed that multiple VR-ST sessions would likely improve their presentation skills in general. Following the experiment, 92% of the participants reported having fun and enjoying VR-ST.

One of the strengths of this study is the use of self-reported data, which allowed participants to share their subjective experiences and perceptions of the VR-ST. This can be particularly valuable in the context of VR training, as individual experiences and perceptions of stress are personal and can be influenced by a variety of factors. However, it is also important to recognize the limitations of self-reported data. The subjective nature of these types of data can be prone to bias and error. In addition, self-reported data may not always accurately reflect objective changes or results.

The limited exposure to VR-ST in the study may have affected the ability of the participants to fully adapt to the technology, but the positive acceptance rate observed in this study suggests that VR-ST has potential as a useful communication skills training tool for public speaking. Additionally, acceptance of a training program is a key factor in its effectiveness, as individuals who are unwilling to use or participate in a training program are unlikely to benefit from it. However, it is important to note that the small sample size may not be representative of the general population. Therefore, more research with objective measures and longer training times is needed to fully assess the effectiveness of VR-ST as a communication skills training tool.

In summary, these results suggest that VR-ST could be a valuable tool to overcome anxiety about public speaking and improve presentation skills, and the participants acknowledged its value.

As part of the exploration of the potential of VR-ST, an experiment including 200 participants was conducted, and two versions of VR-ST were examined:

[2] 80% of the participants.

- One version included gamified direct feedback
- One version provided a pure simulation training scenario [3]

The TAM was used to assess user perception and acceptance of this VR training. The study also examined two other constructs to explore how intrinsic motivation and sensory overload can affect the effectiveness of VR-ST. As part of the general objective of the study, an effort was made to better understand the factors that contribute to the acceptance and effectiveness of VR-ST, which may be reflected in corporate training environments.

Hypothesis 1 of this research states the following:

- **H1** *Direct feedback shows higher technology acceptance than simulation-based feedback.*

It was hypothesized that the VR-ST group with direct feedback would show higher acceptance of the technology, increased intrinsic motivation, and lower complexity compared to the simulation-based group.

Multiple measures of technology acceptance, such as perceived usefulness, perceived ease of use, behavioral intent, intrinsic motivation, and complexity, were analyzed using MANOVA to test this hypothesis. Compared to the simulation-based group, VR-ST with direct feedback showed significantly higher ratings for all measures. Therefore, the results fully support this hypothesis.

However, it is important to consider certain limitations when interpreting the results. In particular, the direct feedback version and the simulation-based version of the VR-ST used different methods to provide feedback and indicate audience attention and participation, making it difficult to directly compare the results of the two versions. The direct feedback version may have used a more intuitive way of showing audience engagement compared to the simulation-based version, thus impacting the high perceived usefulness and perceived ease-of-use ratings reported for the direct feedback version. To address these limitations, it would have been beneficial to measure the effectiveness of all conditions through a pre-post-test evaluation to draw a more concrete conclusion regarding the effectiveness of both versions of the VR-ST.

The following are Hypotheses 2 and 3:

- **H2** *Participants with public speaking anxiety show higher acceptance of technology than participants without public speaking anxiety.*

Although the results of this study did not support the hypothesis that participants with public speaking anxiety were more likely to accept VR-ST, they provided valuable information on the possible barriers to VR-ST acceptance in individuals with high levels of anxiety.

The results could be influenced by a variety of factors. One of the most important factors may be the phenomenon of negative bias toward new or unfamiliar situations in people with high levels of anxiety and their perception that the VR-ST intervention is aversive or

[3] This version does not include a gamified approach.

threatening. Additionally, the immersive nature of VR may also play a role in the reduced acceptance of VR-ST among people with high levels of anxiety. The immersive properties of VR could lead to an increased sense of presence, which, in turn, could lead to increased self-awareness. This increased level of self-awareness could trigger an increase in anxiety, which could lead to a decreased acceptance of VR-ST in individuals with high levels of anxiety.

This result underscores the importance of considering the previous experience and comfort levels of learners when designing and implementing educational technologies. Additionally, to meet the needs of people with high levels of public speaking anxiety, it may be necessary to integrate additional gamification mechanisms or adjust the difficulty level within VR-ST. However, it remains uncertain which specific game elements and game mechanics would be most effective in this context. As such, more research is needed to determine the optimal approach to integrating gamification into VR-ST to enhance the experience of those who fear public speaking.

- **H3** *Participants with prior VR experience show higher technology acceptance than participants without prior VR experience.*

The objective of Hypothesis 3 was to uncover an association between familiarity with VR and acceptance of VR-ST. Despite the researcher's best efforts, no significant correlation was found.

A possible explanation for this result is that the metric used to evaluate the VR experience may have been insufficient. Specifically, the methodology used a single-item scale to rate the VR experience, which proved to have little statistical validity. Furthermore, grading participants into two levels of VR experience based on a single question and additional self-reported information may not have been sufficient to evoke a meaningful association between VR experience and VR-ST acceptance. To better understand the relationship between VR experience and VR-ST acceptance, future research should use more robust measures of VR experience.

In summary, VR can be a powerful tool for corporate training, but it is important to remember that its effectiveness depends on the specific application, the characteristics of the learners, and even the corporate culture. Furthermore, it is important to critically evaluate the potential benefits and limitations of this technology to ensure its effective implementation in training programs. One of the major challenges related to the use of VR in education is the availability and accessibility of the necessary technology and equipment, as well as the technical skills necessary to use the technology effectively. Additionally, there may be concerns that excessive technology dependence may inhibit the development of critical thinking and problem-solving skills.

An area of particular interest for future research is the role of graphics in VR applications. As technology advances, it becomes increasingly possible to create photorealistic virtual environments and avatars. Although this level of realism can enhance the immersive experience, it also raises important ethical questions about the potential consequences of interacting with highly realistic virtual representations of humans. Consequently, it is crucial to conduct further research and examine the impact of photorealistic graphics on VR training and to consider the broad ethical implications related to this topic. This is a highly sensitive topic and should be carefully considered in any discussion of VR and not just in the context of learning and training.

To successfully integrate XR training into organizations and ensure its effectiveness in improving employee performance and skills, several practical challenges must be addressed. In this regard, Palmas and Niermann's [PN21] four-phase model provides a practical framework designed to help companies overcome the challenges associated with integrating XR training. The model consists of four phases (Fig. 7.1) that can be summarized as follows [Pal+22]:

- Phase 1 (Conceptual Design) consists of a systematic approach to identify the needs, goals, and expectations of stakeholders in relation to the implementation of an XR training program. This phase includes conducting a business case analysis to determine the feasibility and potential impact of the XR training and identifying the target audience and their specific learning needs. A key aspect of this phase is the establishment of learning analytics and key performance indicators4 to measure the effectiveness of the training program and monitor progress over time. The technical infrastructure required for the xR training program is also evaluated and identified in this phase, including any potential risks or challenges that may need to be addressed. The goal in this phase is to establish a comprehensive understanding of the project goals and requirements, and to identify any potential issues early on in the implementation process. This allows the development of a detailed project plan that can mitigate risks, optimize resources, and ensure the successful implementation of XR training.

- Phase 2 (Minimum Viable Product) focuses on prototyping the product, which includes the minimum set of features required to validate the product's value proposition with early users. This minimum set of features addresses the core problem or needs of the target audience and allows sharing with a small group of early adopters to collect feedback and data to measure the product's performance. This process allows the development team to validate the training concept and make informed decisions for future development.

- Phase 3 (Production): Further production decisions are only possible after extensive test validation. The features identified in the MVP are now being produced. As part of the first release version, the XR training is now available to a wide range of users. For a successful production phase, the development must be agile and take into account some additional aspects, such as effective communication, change requests, polish [4], and internal marketing.

- Phase 4 (Post-Production) provides ongoing maintenance and support for the XR

[4] The process of finalization of the training application that involves the implementation of aesthetic enhancements and the elimination of technical errors (bugs) to ensure optimal visual appeal and functionality.

training released. This phase involves managing the development lifecycle of the XR training application by ensuring regular maintenance and updates and monitoring and analyzing the data using scientifically validated methods. The effectiveness of XR training can be increased and further developed through systematic observation and analysis of this data. Additionally, internal marketing should support the adoption and acceptance of XR training by providing accompanying news and building an internal user community.

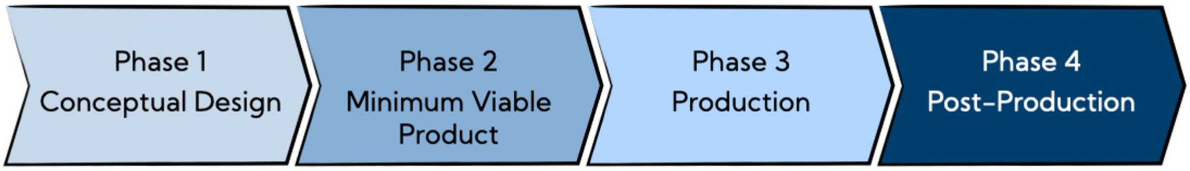


Figure 7.1.: The four-phase model of the XR training. Retrieved from Palmas et al. [Pal+22]

The underlying principles of this model can be extended to an educational context and support its implementation in an educational setting.

The field of education and learning has developed rapidly with the advancement of technology, and the use of video games for learning has gained significant attention in recent years. To explore the potential of using in-game advertising strategies for educational purposes as a way to increase engagement, fun, and motivation among learners, a definition for adverlearning was provided, as follows:

> *"The repurposing of in-game advertising's methods and strategies for conveying learning content and achieving educational goals by applying them to video games."* [PK21]

Adverlearning also has the potential to improve employee engagement and retention in corporate training, especially for future generations who may be more used to digital media and interactive learning methods. Additionally, by making corporate training more attractive, adverlearning could increase employee participation rates and lead to better results on the job.

The main limitation of this concept is that it is still at an early stage of development and research, and more studies are needed to understand its impact on the field of education and learning. In addition, there are ethical considerations when it comes to repurposing advertising strategies for education, particularly in the context of video games for which children and young people are important target groups.

Adverlearning has great potential for innovation. The use of video games and interactive digital media as learning tools has shown potential to increase player motivation and engagement, and the use of in-game advertising strategies that integrate learning content could enhance learning and maintain the fun effect. Adverlearning also has the potential to increase the accessibility and availability of educational resources for learners, especially those who dislike or cannot access traditional forms of education.

In summary, adverlearning is a novel concept that can contribute to the field of education, learning, and corporate training. Although it is still in its early stages and needs more research, there are potential benefits of adverlearning. However, researchers should be aware of ethical considerations and work to mitigate possible negative impacts on learners.

Based on all of these findings, gamification appears to have the potential to positively impact corporate XR training. However, more research is needed to fully understand the extent of this impact and to establish the most effective methodology to implement gamification in corporate XR training.

8. Conclusion

The potential for gamification to have a positive impact on corporate XR training was investigated in this dissertation. A review of the relevant literature and examination of empirical evidence demonstrate the importance of incorporating gamification into XR training and its potential to influence corporate training. The review of literature on several topics related to corporate training provides insight into the current challenges companies face in the context of digital transformation and the need for organizations to support lifelong learning. In particular, the growing role of public speaking and the challenges of generational conflicts have been considered, as these issues are likely to increase in importance in the coming years.

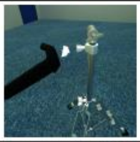
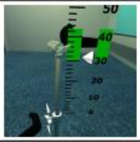
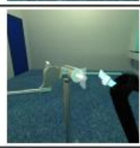
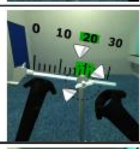
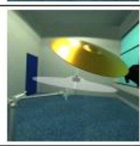
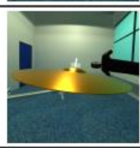
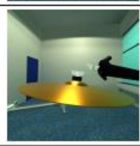
Examining the future of work has highlighted the need for upskilling and reskilling to navigate the rapidly changing labor market effectively. The distinction between hard and soft skills has been recognized as a crucial aspect of understanding the complexities of the future of work. Additionally, the role of skills in shaping the future of corporate training was considered. This review of the literature has provided a solid foundation for understanding the topic of corporate training and has also helped to improve the understanding of the challenges and opportunities facing businesses today.

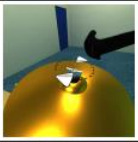
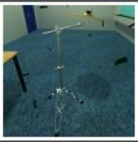
The topics of learning and its theories were examined, followed by an analysis of motivation theories that help to understand the relationship between gamification and video games. In addition, this dissertation provided a more refined definition of gamification. This investigation and analysis allow for a better understanding of the research studies presented and the design of effective learning environments. Through the studies presented, the term XR training was defined and shed light on the potential of gamification in the area of XR, particularly in the context of corporate training. Furthermore, the role that gamification can play in improving the effectiveness of both hard and soft skills training using XR technologies, with a focus on VR, has been demonstrated. The results concerning soft skills training show that VR-based communication training, specifically VR-ST, is an effective and well-received training method and thus suggest that integrating gamified direct feedback mechanisms into VR-ST has the potential to further improve its effectiveness. In addition, the novel approach adverlearning, which has the potential to revolutionize the learning, education, and corporate training sectors in the future, was presented.

In conclusion, this dissertation underlined the importance of considering gamification when designing and implementing XR training applications. In addition, these findings provide a basis for future research in this area.

A. Appendix

A.1. Tutorial steps are arranged chronologically in this list, along with the type of action the user took and an image of the corresponding situation.

Step	Tutorial text	Action	Image
1	Pick up the pole and insert it into the top of the tripod.	One-handed pick up	
2	Pick up the wing nut and attach it to the screw on the tripod.	One-handed pick up	
3	Adjust the height of the pole so that the marker points to the green area, then tighten the corresponding wing nut.	Two-handed interaction	
4	Pick up the horizontal rod and attach it to the mount on top of the pole.	One-handed pick up	
5	Pick up the wing nut and attach it to the screw at the top of the pole	One-handed pick up	
6	Adjust the setting of the rod until the marker points to the green area, then tighten the corresponding wing nut.	Two-handed interaction	
7	Adjust the angle of the cymbal rod so that the marker points to the green area, then tighten the corresponding wing nut.	Two-handed interaction	
8	Pick up the plastic washer and attach it to the end of the cymbal rod.	One-handed pick up	
9	Pick up the felt washer and attach it to the end of the cymbal rod.	One-handed pick up	
10	Pick up the cymbal and attach it to the end of the cymbal rod.	One-handed pick up	
11	Pick up the felt washer and attach it to the end of the cymbal rod.	One-handed pick up	
12	Pick up the wing nut and attach it to the threading at the end of the cymbal rod.	One-handed pick up	

Step	Tutorial text	Action	Image
13	Fasten the wing nut.	One-handed interaction	
14	Congratulations, you did it!	None	

A.2. Descriptive findings and correlations [1]. Retrived from Palmas et al. (2021)

[1] *p < .001, **p < .01, ***p < .05

	M	SD	SK	KU	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) VR-Experience					(.–)							
(2) Training-Experience					-.017	(.–)						
(3) Public Speaking Anxiety					.124	.140*	(.–)					
(4) Perceived Ease Of Use	5.94	1.02	-1.18	0.92	-.196**	-.138	-.358**	(.84)				
(5) Perceived Usefulness	5.31	1.08	-0.60	-0.15	-.097	-.141*	-.177*	.547**	(.77)			
(6) Intrinsic Motivation	6.13	0.91	-0.90	-0.14	-.161*	-.094	-.297**	.596**	.480**	(.76)		
(7) Complexity	5.72	0.93	-0.75	0.09	-.212**	-.024	-.284**	.385**	.219**	.341**	(.73)	
(8) Behavioral Intention	5.73	1.09	-0.82	0.28	-.140*	-.075	-.225**	.530**	.615**	.573**	.410**	(.80)

(*p < .001, **p < .01, ***p < .05)

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Acronyms

AR augmented reality.

DoF Degrees-of-Freedom.

ERG Existence, Relatedness and Growth.

MR mixed reality.

PRCS personal report of confidence as a speaker.

TAM technology acceptance model.

VR virtual reality.

VR-ST virtual reality speech training.

WPM words per minute.

XR extended reality.

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