Which Factors Promote and Inhibit the Technology Acceptance of Immersive Virtual Reality Technology in Teaching-Learning Contexts? Results of an Expert Survey

Carolin Pletz
University of Stuttgart, Stuttgart, Germany
pletz@ife.uni-stuttgart.de

Abstract—Although immersive virtual reality (IVR) is now accessible for large-scale use due to rapid technological developments, there appear to be few organizations in Germany that are already actively using this technology on a large scale in education and training. Therefore, little is known about the technology acceptance. Questions arise as to how the technology acceptance can be explained and which technology-specific influencing factors can be identified in the field of training. 15 persons from 13 organizations, who are experienced in using IVR in teaching-learning contexts such as training, were interviewed in an expert survey to identify promoting and inhibiting aspects of the technology acceptance of IVR in teaching-learning contexts. The results provide information about personal, organizational and, technology-related promoting and inhibiting aspects for trainers and training participants. Furthermore, general aspects which are decisive for future use in the companies are derived.

1 Introduction

Due to a change in cost and dimensional factors as well as the release of commercially available hardware in 2015, immersive virtual reality technologies (IVR) are now accessible for large-scale use [1]. "Virtual Reality (VR) refers to computer-generated real-time representations of real or fictional environments that are three-dimensional and interactive" [2, p.1]. Unlike desktop-based virtual environments, head-mounted displays (HMD) allow users to truly feel like they are part of these immersive virtual environments [3].

The use of IVR is associated with diverse possibilities, especially in teaching-learning contexts in vocational education and training. For example, technical training can be carried out without the presence of real machines and equipment, or without risking expensive damage due to errors [4, 5]. However, for these possibilities to be fully exploited, IVR must be accepted and implemented by the potential users in the

organizations [6]. Since the use of a technology does not automatically correlate with its availability, it may be necessary to investigate why certain target groups accept technology or reject it to better predict and influence technology use [7].

This study focuses on the perception and assessment of IVR by organizations and their employees in teaching-learning contexts. Expert interviews will be used to examine the reasons why IVR is implemented in companies and which promoting and inhibiting factors for the technology acceptance of IVR can be inferred.

2 Theoretical Background and State of Research

2.1 Technology acceptance

Acceptance is defined "as a positive reception of an idea, not only as reactive tolerance but more in the sense of active willingness, […] which leads to adoption (or rejection) of an innovation" [8, p. 259]. Perhaps the best-known and most extensively studied model to investigate and explain individual technology acceptance of users is the Technology Acceptance Model [TAM; 9, 10]. Based on the Theory of Reasoned Action [11, 12] and the Theory of Planned Behavior [13,14], the TAM was developed with the intention of explaining and predicting the use of information technologies [7]. Perceived usefulness and perceived ease of use of a technology are assumed to be the main predictors for the intention of (potential) users to apply the technology. Usefulness includes the user's assessment of whether the technology will bring a certain added value, e.g., a reduction in workload. Ease of use is defined as the estimated effort required to use the technology. Since the intention of use does not automatically lead to actual use, it refers to "attitude-related acceptance", whereas actual use represents "behavioral acceptance" [15]. Accordingly, technology acceptance essentially includes both: the intention to use a technology and the actual use itself.

In various developmental stages of the model, additional influential factors have been added to increase the theoretical accuracy and explanatory power of the model. Therefore, in TAM 2 [10], social and cognitive factors that determine perceived usefulness were added, which in turn were combined with factors that influence ease of use, such as the perceived enjoyment in TAM 3 [16, 17]. Essentially, the extension factors of the TAM can be divided into three groups: personal factors, such as age or experience with the technology; organizational factors, such as user training or support; and technology-related factors, such as the completeness of the information provided [15, 18]. Based on the TAM, there are studies that investigate the acceptance of learning apps [19], learning management systems [20], medical technologies [21, 22], social media [23], computer- and web-based learning environments [24, 25], augmented reality technology [26], as well as desktop-based virtual environments [27, 28].

2.2 Acceptance of IVR

Pletz and Zinn [18] investigated the technology acceptance of IVR in technical domains on the basis of the TAM using structural equation modeling. According to their results, perceived usefulness and ease of use influence the intention of use of IVR. Older people rated ease of use lower than younger ones. Persons with experience with the technology rated the usefulness, ease of use, and intention to use significantly higher than persons without experience. In addition to these results, Shen et al. [29] found that the social norm was the strongest predictor for the use of IVR for student learning.

Enjoyment has generally been found to be a strong factor in fun-oriented technologies [30]. The results of Manis and Choi [31] in the consumer context confirm an influence of perceived enjoyment on the decision to acquire IVR hardware. Age, previous experience, and curiosity influenced the perceived ease of use. However, due to the focus on the consumer, the results of the study primarily refer to the use of IVR in private contexts, i.e., the gaming sector, and less in professional contexts. Hedonistic advantages of the technology likely play a more important role in private contexts than, e.g., its usefulness. However, the hedonistic motivation was rated highest by prospective preservice teachers compared to all other aspects in the study of Bower et al. [32]. Herz and Rauschnabel [33] focused their research in the consumer context on the technology-specific aspects of wearability, immersion, and user concerns. While hedonistic and utility aspects, as well as wearing comfort had an influence on acceptance, virtual embodiment, and virtual presence had no influence. Concerns about privacy and health are relevant influencing factors, too. However, it should be critically noted that the majority of the participants had never used IVR at the time of the survey. An influence of virtual presence was not demonstrated in the study by Sagnier et al. [34], either. Motion sickness turned out to have a negative impact on acceptance among students who were given a virtual assembly task. Furthermore, the results showed that the personal innovativeness of the users had a positive effect on the perceived usefulness.

tom Diek et al. [35] used qualitative interviews to investigate the acceptance of an IVR application among tourists in a national park. In addition to the TAM factors, the authors identified hedonistic factors, e.g., perceived enjoyment, and emotional factors, e.g., place attachment, as influential aspects of acceptance. The open identification of potential influencing factors through the qualitative approach is mentioned as an advantage of the study. However, it should be noted that most of the test persons used IVR for the first time during the study. In a qualitative interview study, Mütterlein and Hess [36] found that the factors 'content quality', 'initial excitement', 'isolation', and 'distraction' were neglected as influencing factors in other studies.

Overall, the state of research regarding the acceptance of IVR technology can be described as expandable, especially in the case of IVR in professional contexts such as training. There are only a few definite results on the technology-specific factors influencing the acceptance of IVR, such as motion sickness or wearing comfort. Most of the studies listed above employ a quantitative approach of investigating technology acceptance. The disadvantage is that only individually selected potential influencing

factors can be surveyed without obtaining a holistic picture of other aspects that were not expected in advance. Studies therefore often consider the transfer of a general model such as TAM [36], instead of identifying (technology-specific) factors anew. However, the identification of new technology-specific factors and factors that are relevant for teaching-learning contexts could expand the state of knowledge. Mütterlein and Hess [36] suggest further qualitative studies to examine the causality of individual factors and subsequent quantitative studies to investigate the extent of these influences.

In most studies, the subjects are shown a single specific IVR application once, often for the first time, before they are asked to answer a questionnaire. In these cases, however, the results are either highly dependent on the respective technical implementation and design of the concrete IVR environment, or the respondents are not experienced enough with the technology to be able to make a meaningful assessment, e.g., about usability. In addition, the end users of IVR technology, e.g., the participants in IVR training, are more likely to be asked about their acceptance of the technology than other stakeholders, such as trainers or management.

3 Research Question

The present study aims to generate a comprehensive explanation and description of the acceptance of IVR technology in education and training in organizations. The following question is addressed:

What factors promote or inhibit the acceptance of IVR technology by trainers and training participants?

4 Methods

4.1 Research design

To answer this research question, a qualitative approach was chosen for the study. In addition to the aforementioned criticism of quantitative analyses, it can be assumed that, due to the novelty of the technology, only few IVR applications have been actively used in teaching-learning contexts to date. Merely few persons in organizations already have extensive experience with IVR technology and use it regularly, which greatly limited the sample. Guideline-based semi-structured expert interviews were conducted. The approach of semi-structured interviews is particularly suitable "to validate previous findings but also leave room to identify gaps" [36, p. 5]. The interview guide was created on the basis of the existing literature about acceptance of IVR (see Appendix).

4.2 Participants

A comprehensive search was conducted for organizations in German-speaking countries that use IVR technology in teaching-learning contexts to identify suitable interview partners. Organizations were contacted based on corresponding press releases, IVR news on their website, participation in IVR research projects, or at trade fairs. The following criteria were defined for the selection of interview partners to ensure their expertise:

- Use of IVR technology with appropriate VR hardware, i.e., Head-Mounted Display (HMD); not desktop-based.
- Use of IVR technology in teaching-learning contexts (e.g., training).
- Active use for at least six months, i.e., the IVR applications have been operational for at least six months and have been in use since then.
- The interviewee has experience with IVR, either in the conception or testing of the technology or he/she is a trainer who uses IVR in his/her own training.

N=15 interviews with persons from 13 organizations in Germany and Switzerland were conducted. The interviewees were all male and aged between 24 and 59 years (M = 40.47 years; SD=11.19 years). Table 1 shows their professional background and details about the organizations.

Most of the interviewees either initiated the implementation of the technology in training themselves or accompanied it from the beginning. Before the actual implementation in training, various test runs were carried out in all organizations. The IVR training applications included primarily learned process sequences (e.g., when packaging components or assembling a machine), treatment methods (e.g., by simulating an operation or a patient), and hazard training (e.g., in road traffic or in the event of a fire). The training participants in the organizations were heterogeneous and included craftsmen, students, trainees, doctors, warehouse logisticians, or service personnel of different educational backgrounds, ages, and genders. The trainers were mostly experienced employees with additional training in the respective field, instructors, or vocational school teachers, as well as heterogeneous in terms of age.

In terms of hardware, most respondents used HTC Vive (Pro). Three organizations (additionally) used Oculus Go or Oculus Quest (I6, 14, 15). At the time of the study, the applications had mainly been created externally by VR service providers while the data preparation, creation of the scripts, or the methodical-didactical conception were partly done internally. Two organizations (I4, 15) created the applications completely internally within a VR working group to be able to make adjustments to changes in the training content faster and more cost-effectively.

Table 1. Information about the participants and organizations.

	Sector of organization (number of employees)	Profession	Personal experience with IVR	Frequency of IVR trainings in organization*
I1	Medical Technology (65.000)	IVR Project Team Member	Conception of IVR training Presentation of IVR applications to interested persons	3 trainings per year
I2	Medical Technology (65.000)	Head of Digital Communication	(User-) testing of IVR	6 trainings per year
I3	Print and Media Technology (< 50)	IVR Project Manager	Conception of IVR training Testing of IVR Presentation of IVR applications to interested persons	60 trainings per year
I4	Transportation/Logistics (18.000)	Head of Training Centre	Conception of IVR training Presentation of IVR applications to interested persons	12 trainings per year
I5	Medical Technology (65.000)	Trainer	Use of IVR in training	4 trainings per year
I6	Safety Technology (< 50)	Managing Director	Conception of IVR training	2 trainings per year
I7	Print and Media Technology (600)	Trainer	Conception of IVR training Use of IVR in training	Min. 1 training per year
I8	Automotive (175.000)	Head of Corporate Security	Leading the IVR working group	12 trainings per year
I9	Transportation/Logistics (17.000)	Head of Industrial Engineering	Conception of IVR training Presentation of IVR applications to interested persons	Daily
I10	Medicine (35.000)	Trainer	Conception of IVR training (User) testing of IVR Use of IVR in training	Min. 1 training per year
I11	Automotive (62.000)	IVR Project Team Member	Conception of IVR training (User) testing of IVR	No specification
I12	Mechanical Engineering (1.100)	Trainer	Use of IVR in training	3 trainings per year
I13	Medicine (4000)	IVR Scientific Assistant	(User) testing of IVR	90 trainings per year
I14	Transportation/Logistics (33.000)	Head of Educational Media	Leading the IVR working group	48 trainings per year
I15	Automotive (16.000)	Head of 3D, VR & AR	Leading the IVR working group	12–14 trainings per year

Notes: * Specified training group sizes between one and twelve persons.

4.3 Study procedure

First, all participants were informed about the aim and the procedure of the study and gave their written consent to the recording and scientific use of the interviews. The interviews were conducted over the phone and lasted approximately 45 minutes. In a next step, they were transcribed, removing dialect, pauses, stutterers, and delay sounds.

At the beginning of each interview, the subjects were asked about demographic, technological, and training aspects of IVR in their organizations (example: "Please describe an IVR training application."). This was followed by general questions regarding technology acceptance (example: "What factors do you think influence user acceptance of IVR?"). In-depth questions on potential personal, organizational, and technology-related factors were used when participants did not address these issues themselves (example: "To what extent have you noticed influences of age on acceptance?"). Furthermore, concerns and general conditions were questioned. For example, the interviewees were asked to estimate the maximum time that training participants can work or learn with an HMD, e.g., before it becomes uncomfortable or exhausting. Finally, the respondents were given the opportunity to share additional experiences.

4.4   Data analysis

The data analysis procedure was based on the qualitative content analysis according to Mayring [37] using the software MAXQDA (version 12). The individual categories for the category system were formed in an iterative process, both deductively on the basis of the existing literature and inductively on the basis of the statements made in the interviews (see Fig. 1). Within this process, similar data were grouped into categories:

1. First, two interviews were coded by two independent coders based on a first deductive draft of the category system. Based on the reported studies on the technology acceptance of IVR, e.g. the categories usefulness, ease of use, personal influences such as age and previous experience, social influences, as well as the technology-specific aspects motion sickness and wearing comfort were deductively formed as potential influencing factors on user acceptance. The results of the first coding of the two coders were compared and discussed, and further categories were inductively formed. It was recognized that a separate consideration of the factors between trainers and training participants was necessary to reflect individual needs in a meaningful way. Furthermore, general statements on the use of IVR in the organizations and acceptance without reference to an actual user group were classified into a separate category. Therefore, the category system was adapted accordingly, and sub-categories were re-sorted.
2. Five interviews were coded independently by the two coders using the revised version of the category system. Once again, an intensive exchange about the coding and the formation of further inductive categories occurred. Subcategories for all three levels of the general organization, trainers, and training participants were added.
3. On this basis, all 15 interviews were coded by the two independent coders. In a final discussion and revision process the categories and codings were discussed, and the interrater agreement was calculated. A total of 1.132 codings were assigned to 9 categories and 53 sub-categories. With the help of this iterative process, problems regarding the differentiation or definition of the categories could be identified

and reduced at an early stage. Differences in the approach of the coders could be detected. Therefore, the interrater analysis served as a means to verify, secure, and improve the quality of the coding process. With this procedure, interrater agreement values between 73.81% and 96.19% were achieved for the categories, i.e., acceptable to very good values [38, 39].
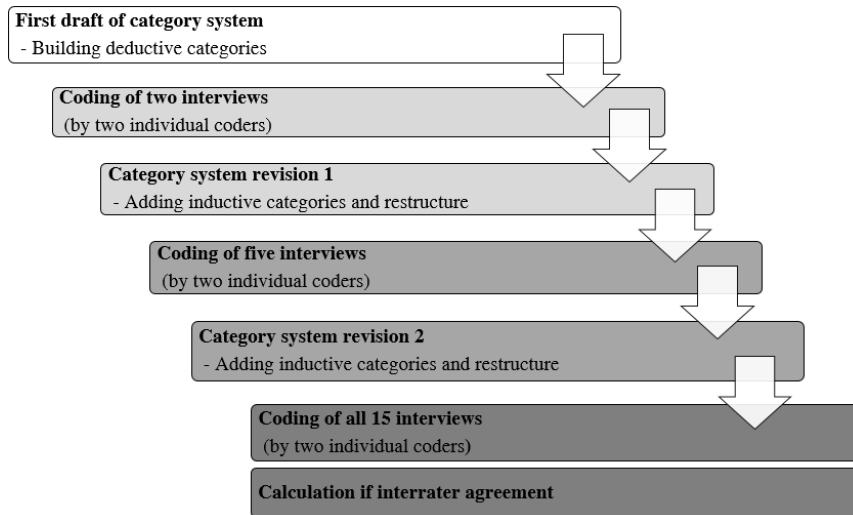

Fig. 1. Process of the data analysis

5 Results

The following results are structured and summarized according to the developed category system. Tables illustrate the category system with information on the number of codes and are intended to give an indication of how many interviewees commented on an aspect. Selected quotes represent the categorization.

5.1 Current status of IVR in training

Different variants for the use of IVR in training can be summarized regarding the *setting* or the *methodical-didactical concept*. The fact that, depending on the number of HMDs available, only a limited number of people can use the technology simultaneously was a challenge. The two most frequently mentioned variants for solving this problem by the respondents were, on the one hand, that one participant ran through the application alone, while the rest of the training group performed another task, e.g., a group task (I7, 8, 9, 10). On the other hand, it is possible to mirror the IVR image on a monitor so that the rest of the group could watch (I2, 8, 9, 10, 12, 15). To reduce waiting times, small groups were preferred. To keep the attention of the audience, two organizations chose partner work as a social form (I7, 15). While one person wore the HMD and had to fulfil a task, the second person acted as a supporter and provided

training information. At the time of the study, only one organization offered the possibility of collaborative work in an immersive scenario (I10). The importance of a debriefing of the experience was emphasized because individual questions could be reflected and discussed. In two interviewed organizations, the trainers played an active role during the IVR simulation by giving necessary hints or even actively controlling the scenario (I10, 8). In two other organizations, two trainers were present simultaneously during the training—one person for the technical expertise and one person who took care of the IVR (I5, 12).

It was emphasized across all organizations that IVR should not and cannot be a substitute for conventional training but rather a ***supplement***. In this context, three organizations had "backup solutions" available, in case people did not want to or could not use IVR, e.g., showing the scenario desktop-based via tablet or laptop (I1, 3, 4). The respondents were asked to give an assessment of the maximum duration of use, i.e., how long one could learn and work with an HMD in a teaching-learning context. The recommendations varied from a few minutes (I2, 11) to unlimited learning time (I5). However, the majority of respondents indicated 20–30 minutes as a reasonable learning time with IVR. It is possible that, with more frequent use, a habituation effect may occur that allows a gradually longer period of use.

5.2 Implementation of IVR in the surveyed organizations

The interviewed persons made various statements about the acceptance of IVR technology in the company without reference to a specific user group but with a general reference to the organization itself (see Table 2).

When asked why IVR was implemented for training within their own organization, the interviewees gave many different reasons as to why they found IVR ***useful*** and that it ***added value***. This aspect was described as a necessary condition for a long-term useful application and seems to be elementary due to the frequency with which it was mentioned. In this context, four people stated that, before ever using the technology, they were concerned about whether IVR is actually beneficial and as realistic as it promises to be (I5, 7, 8, 14). Three respondents stated that they had no prior concerns whatsoever about implementing the technology (I2, 12, 13).

Table 2. Acceptance of IVR in the organizations

Category: Usefulness / added value of IVR		N Codes	N Persons
1 Added value in general		20	11
2 Promote digitalization		20	10
3 Promote prestige		9	8
4 Cost savings / return on investment	4.1 General statements	8	5
	4.2 Profitable	11	8
	4.3 Not profitable	4	3
	4.4 Profitable in the future	2	1
5 Useful aspects for training		58	15
Category: Further promoting or inhibiting aspects for acceptance		**N Codes**	**N Persons**
1 Advancing or inhibiting persons / institutions		17	10
3 Aspects of hardware		9	8
2 Effort for creation of IVR applications		8	6
3 Proof of qualification		1	1
Category: Concerns before implementation of IVR		**N Codes**	**N Persons**
1 Financial concerns		7	5
2 Motion sickness		6	5
3 Concerns regarding usefulness		4	4
4 Concerns regarding usability		4	4
5 Lack of acceptance		3	2
6 No concerns		3	3

The most frequently mentioned aspect regarding the usefulness of IVR was the intention to ***promote digitization*** in the organization. Most organizations appeared to have purchased IVR as a modern, "hyped-up" technology to demonstrate their digitization strategy. In some cases, they identified use cases in which the technology was useful later on (I2, 5). The organizations were particularly interested in gathering experience with the technology and its functionality, with the knowledge that not everything can be perfectly implemented right from the beginning:

> *"We simply said, we just had to start with an MVP [note: Minimum Viable Product], get some experience [...]. We just started, we said 'we need an innovative application' and then hoped that everything would work." (I2, Head of Digital Communication, Medical Technology)*

Closely related is the aspect that most organizations wanted to increase their ***prestige*** by using this technology to present themselves as innovative and future-oriented companies in a marketing-effective way:

> *"Of course, certain marketing aspects also play a role that we as enterprises present us positively: We are up to date, we are participating in digitization in an area in which there has not yet been any real digitization to this extent." (I6, Managing Director, Safety Technology Sector)*

The estimated ***cost savings*** through IVR or a return on investment played an important role as an aspect of usefulness for the organizations. This factor was most often expressed by respondents as a pre-acquisition concern (I3, 4, 6, 9, 15). Howev-

er, eight respondents indicated that appropriate calculations had been made in advance, showing that IVR would be profitable at the current time of the survey or in the future (I1, 2, 5, 8, 9, 11, 14, 15). Cost savings can be achieved through IVR, e.g., by saving travel expenses for visits or training, costs for expensive machines and equipment that do not have to be purchased separately or would stand still during training, and the possibility of being able to train faster and more flexibly. In contrast, three respondents said that the investment in IVR was not worthwhile for their company at that time (I6, 10, 12). This was justified by the high cost of data preparation in particular. The interviewees named further aspects why IVR is useful for education and training, including the ability to **visualize** something that is not visible in reality, more **effective learning**, and that mistakes have no real effect.

Further promoting and inhibiting factors for the acquisition of IVR were identified in addition to usefulness. The most frequently named aspect relates to **advancing or inhibiting persons/institutions** within the organization. For example, most respondents reported that they or individual colleagues had taken the initiative to acquire the technology, or that these people were necessary:

> *"I think a decisive factor is that you have someone in the company who is convinced of this and is correspondingly prepared to approach it with a certain level of commitment." (I3, Project Manager Research Projects, Print and Media Technology Sector)*

The decisive factor here was to convince the **management** of the technology to receive the necessary support and, especially, the necessary budget. The majority of respondents reported that management supported and promoted the use of IVR. However, the support was less in terms of content, i.e., in the form of naming concrete use cases, but rather in terms of money or media impact (I11). The **works council**, on the other hand, was named by one respondent as a critical authority that had to be particularly convinced of IVR with regard to health concerns or data protection (I15).

The **cost of hardware** was not perceived equally. For larger companies, it seemed to be negligible at the current price (I1) whereas, e.g., a vocational school needed to calculate exactly whether a new pair of VR-glasses can be acquired (I3, 7). It might be beneficial for smaller institutions to be able to borrow and test the technology before purchasing it. However, two respondents were critical of the **IT security**, which has to be proven in the organization at great expense before a new technology can be connected (I11, 12). This led to reservations regarding an initial purchase. Another critical factor was the **effort** (cost and time) involved in creating the applications. The VR market in general and the internal digitization processes regarding digital data in particular were considered not yet mature enough:

> *"At the moment we are mainly concerned with improving the software, how we create trainings. This is a lot of effort every time, these are very high costs and this is very, very individual [...]." (I11, VR Project Team Member, Automotive Sector)*

One person brought up the question of the extent to which a VR training can be recognized as **official proof of qualification**, e.g., by insurance companies or professional associations (I6). This is a significant factor for the further implementation of

corresponding training. For most organizations, however, this aspect did not seem to play a role yet because it was only mentioned once.

5.3 Acceptance factors of trainers

In the interviews, various statements were made as to which aspects could be relevant for the acceptance of trainers for the use of IVR in training (see Table 3).

Table 3. Acceptance of trainers

Category: Acceptance factors of trainers		N Codes	N Persons
1 Usefulness		5	3
2 Personal factors		8	5
3 Organizational factors	3.1 User training / support	7	5
	3.2 Support in conception	5	5
	3.3 Involvement in implementation	4	3
4 Technology specific factors	4.1 Effort for setup	23	11
	4.2 Reliability / availability	9	5
	4.3 Adaptability of content	3	2
	4.4 Limitations	2	2
Category: General assessments of IVR		N Codes	N Persons
1 Trainers		6	6

The statements regarding the intensity of the trainers' acceptance reveal a mixed picture. Although most of the employed trainers would most likely view the use of IVR as generally beneficial, however, a certain reluctance becomes apparent in some cases. Three respondents stated that the trainers were sometimes rather sceptical about the technology, e.g., because they questioned its usefulness or were initially afraid of using it (I8, 13, 15). In the following, the identified factors influencing acceptance are described in more detail in the corresponding sub-categories.

Usefulness was named as highly important. According to the interviewees, it was inevitable that the trainers recognized the ***added value*** of IVR for their work to promote the use of the technology. This means that it should not be used just for the sake of the technology. The added value for the trainers themselves was, e.g., that they could work faster and with better results when using IVR (I5), that the technology could be used specifically in the event of difficulties in teaching knowledge (I3) or that they could present themselves to the outside world as an innovative person (I7):

> *"So it must be clear to the student as well as to the teachers: Hey, that's not a gimmick that they just bought because they have a little money as a company for some reason or another, and nothing else has come up that is better than buying a VR-system. Because when you get to that point, you can better invest your money in training for your trainers for all kinds of other things instead of buying technology. But it must be very clear that we have something that has a benefit in this and that aspect and that we are convinced by this [...]. There must be skills and possibilities to convince participants*

> *as well as trainers of these benefits, and finally, the financial back-*
> *ers and managers must be convinced that there is a benefit. So with-*
> *out relevance, just to have it, it makes no sense." (I10, Project Man-*
> *ager Research Projects, Medical Sector)*

Personal factors were identified. According to the interviewees, a certain ***openness towards new technologies and new approaches*** played an important role for the acceptance of the trainers. Younger trainers were generally better and faster when operating IVR, while the intention of use was not as affected by age:

> *"By the way, age is not important." (I3, Project Manager Research*
> *Projects, Print and Media Technology Sector)*

Organizational factors were addressed. The aspect most frequently cited by respondents was the provision of ***user training and support*** opportunities for trainers to promote acceptance and to reduce initial fears. The trainers should be introduced to the use and application of IVR in advance to ensure that they have a perfect command of the technology (I1, 3, 5). In addition, quick user support in case of problems was considered elementary in order to receive instant help during a training course (I1, 9).

Several respondents mentioned that trainers had to deal with how IVR can be meaningfully integrated into their teaching. They might have to ***invest time and effort in the design of new courses***, and they might have to take on a new role within the concept (I11, 13, 15). Depending on the amount of work involved, there might be scepticism on the trainer's side because of this. Another important aspect was to include all participants in the course even though only one of them could use the HMD (see also Section 5.1.):

> *"Yes, there is currently also a certain amount of work for the*
> *trainers to integrate it into their learning concept. This is less about*
> *VR-hardware. So, I would say that the trainers don't need more*
> *time, if they have a new training, until they can handle it. They go*
> *through the content once. But then it's more the job of the trainers to*
> *say, 'I'll integrate it into this and that learning module'." (I11, Pro-*
> *ject Team Member VR, Automotive Sector)*

One option for promoting acceptance was to involve the trainers in the implementation process of the technology early on and to take their feedback into consideration. This way, they could serve as multipliers (I9).

Technology-related factors were mentioned. The most frequently named aspect in relation to the IVR technology itself referred to the ***effort involved in setting up or installing the IVR system***, or to problems that can arise in this context and negatively influence the overall acceptance. This factor seems to be elementary for the acceptance of the trainers because it was mentioned most often compared to all other categories. IVR currently includes various trackers, the HMD, and a PC or laptop. The connection of the individual components does not always work perfectly and can present challenges to inexperienced users as well as be time-consuming to use, depending on the number of systems (I1, 2, 8, 10, 11, 12). The participants asked for improved plug-and-play solutions that are less error-prone and easier to set up. Simple hardware also seemed beneficial for acceptance:

> *"Yes, as already mentioned in the other points: Quick and easy availability and learnability. These are very important aspects. I don't want to spend a lot of time building such a system. I don't want to spend a lot of time learning the software. So, the software and the whole technology must work as free of errors as possible. Because if I'm busy troubleshooting all day long, then I just don't enjoy it. So, it has to be a fast, easy availability. That is a very decisive factor in my eyes." (I10, Project Manager Research Projects, Medical Sector)*

The *reliability* and *availability* of the IVR system was also closely related to this. If the trainers could not be sure that the application runs smoothly and does not crash immediately in the event of minor faults, they would not use it. The same applies if the trainers needed to have a high level of competence to be able to correct errors. In addition, the hardware should be optimized, e.g., in terms of battery life (I4, 6, 8, 10, 12).

Two respondents stated that it was advantageous for the trainers to be able to *adapt* the IVR *content* themselves (I3, 7). This increases flexibility and thus acceptance. Individual training success could possibly be better controlled by flexible adaptations to individual persons. However, it was also said that this would involve a lot of effort due to the in-depth familiarization with the VR system.

5.4 Acceptance factors of training participants

The interviews contained various statements about possible promoting and inhibiting factors on the acceptance of the training participants, according to the assessment of the experts interviewed, as well as the intensity of acceptance (see Table 4). Two respondents indicated that they had concerns about the acceptance of IVR by users before its introduction (I4, 15). However, the interviewees' statements regarding the evaluation of IVR consistently showed that the majority of training participants in the organizations gave positive feedback regarding the use of IVR according to the interviewees. In fact, this assessment was more positive than that of the trainers.

Table 4. Acceptance of training participants

Category: Acceptance factors of training participants		N Codes	N Persons
1 Usefulness	1.1 Added value in general	27	13
	1.2 Increase motivation	19	14
2 Personal factors	2.1 Age	18	12
	2.2 Openness / affinity for technology	16	11
	2.3 Experience with IVR	21	11
	2.4 Health related issues / motion sickness	33	15
3 Organizational factors	3.1 User training / support	12	9
	3.2 Adaptation of training concepts	5	5
	3.3 Over or under challenge in content	3	3
	3.4 Involvement in implementation	1	1
	3.5 Influence of trainers	10	7
4 Technology specific factors	4.1 Usability / ease of use	23	11
	4.2 Wearing comfort	20	12
	4.3 Immersion	18	8
	4.4 Cables	10	7
	4.5 Hygiene	8	5
	4.6 Security	9	8
	4.7 Resolution	7	5
	4.8 Haptics	7	5
5 Social factors	5.1 Social isolation	21	15
	5.2 Data protection	5	3
	5.3 Looks strange	1	1
Category: General assessments of IVR		**N Codes**	**N Persons**
1 Training participants		21	12

Usefulness played a central role for the overall acceptance on the level of the training participants as well, as the coding shows. IVR must offer a recognizable added value for the users themselves, e.g., through better opportunities to practice procedures (I7, 11), a reduction in physical effort (I10), or safer training (I4, 8). There must also be recognizable relevance to their own profession. The technological possibilities and advantages must be emphasized and made clear to the participants, e.g., by superiors, project managers, or trainers.

Although IVR should not be perceived as a mere gimmick, the respondents assumed mutually that the new technology can ***increase the motivation*** of the training participants. Through playful approaches, e.g., the inclusion of small challenges (I1, 6, 11) the training day would be loosened up (I4, 12), the learning material might become more memorable (I4, 11), and the participants would have more desire to learn something new (I3).

Personal factors were addressed on this level, too. Most of the interviewees did not consider the ***age*** of the training participants a significant factor for acceptance, according to the assessment regarding the trainers. However, older people were often more cautious and needed longer to learn how to use the technology:

> *"One has naturally an expectation that all young people go 'Woohoo' and want to use it, and all older ones rather say, 'I'd rather not'. From experience, I cannot confirm that. So, I think this is not an age issue. The general use, which I think is a little bit related to age, is: 'How fast I get along in this world, how fast I get to know the interactions'. But even there are definitely exceptions." (I1, Project Team Member in the area of new technologies, Medical Technology Sector)*

This is closely linked to ***openness to technology and change*** or an ***affinity for technology***, which in turn is attributed to younger people as 'digital natives' (I8) and experience with gaming (I7, 10, 11). Acceptance was higher among those people.

According to the interviewees, the ***previous experience*** with IVR had a beneficial or inhibiting influence on the acceptance of the participants, depending on the application. The quality of the already experienced IVR was particularly decisive here (I2). If the quality was good and the experience was positive, the acceptance of the technology in the training was also higher, and the participants became familiar with it faster. However, the applications would be compared more critically, and people would make more clear what additional possibilities they liked to have (I3). The quality, e.g., in the gaming sector, can sometimes be significantly higher than in more purpose-related training applications (I6, 11). If previous experiences were negative, e.g., because the person had experienced ***motion sickness***, a greater reluctance to using the technology was observed (I2). The occurrence of motion sickness was the second most frequently named concern by respondents prior to purchase (I3, 6, 9, 11, 14). However, the majority of respondents reported that either none or only a small proportion of users (between 1–10%) were actually affected by dizziness or nausea during use. People who experienced motion sickness rejected using this technology, and companies had to offer alternatives (see "backup solutions" in Section 5.1).

Organizational factors included that the users received ***user training*** or were sufficiently introduced to the operation of the system to positively influence acceptance and to reduce any initial fear of contact (see also usability in Section 5.4). The interviewees described that ***training concepts*** had to be ***adapted*** to the use of the technology to be able to use it meaningfully and thus ensure user acceptance as well. This includes the meaningful selection of IVR content and setting (I1, 15), the creation of collaborative learning platforms (I14), or even a mandatory use of the technology to demonstrate its potential (I5). The involvement of users in the implementation process was considered helpful:

> *"Of course, we also achieved a certain degree of motivation by being one of the first to try this out in the area of vocational training at vocational schools. That we could always tell them: 'Whatever feedback you give us now and whatever you tell us about improvement possibilities, about changes in the user interface or the use of the controller, or whatever else you tell us, it flows directly into the development of the system.' This means that we were able to motivate all test participants, be they trainers or trainees, to deal with it in detail and have always had very intensive feedback rounds." (I3,*

Project Manager Research Projects, Print and Media Technology Sector)

In the current stage of development, the training participants did not use IVR technology independently in any organization but always under the supervision of the trainers. This means that the trainers were responsible for *user support*, which was considered crucial for the users in case of problems with the technology. According to the interviewees, the *trainers themselves* could influence the way users perceived and evaluated the technology with their introduction to IVR. It seemed especially relevant to arouse the users' curiosity (I11, 12). The trainers acted as multipliers—therefore, a necessary condition was that they themselves were convinced of and familiar with the technology (I9, 11).

In addition, a *balance between over and under challenge* should be considered. Participants have to learn the operation of a new technology at the same time as learning new content. Neither an operation that is too challenging nor an application that is too trivial would be effective in this case (I6, 7, 11).

Technology-related factors included *usability* or *ease of use* as a significant factor that influence acceptance. It is especially important how intuitively the controllers can be operated. Most of the interviewees stated that the training participants needed about 5–10 minutes to learn how to use the controllers. However, it was also reported that, at the time of the study, the interactions were kept as simple as possible, e.g., as few buttons as possible were used (I4, 11, 15). Looking into the future, it was considered desirable to control the system only with one's own hands instead of controllers (I1, 11, 14).

The *wearing comfort* of HMDs is related to the user-friendliness and one of the most important aspects within this subcategory according to the coding. The size and weight (I1, 2, 10, 12) the adaptability of the straps on the head (I4, 13) and the possibilities to put on the VR glasses comfortably even if you have to wear glasses (I7, 9, 10, 12) were central aspects of this category. With regard to optimization options for increasing acceptance, the current *cable-bound* nature of HMDs was mentioned several times by the respondents. The increased use of wireless glasses was desirable for this purpose:

> *"In general, more in terms of mobile applications. The performance in mobile VR- glasses would have to improve significantly. If you sum it up like this, this means that the cables have to be removed from the glasses." (I15, Head of Department 3D-Multimedia, VR & AR, Automotive Sector)*

The *resolution* of HMDs could be optimized (I11, 12, 15) although other interviewees did not assume that it has a relevant influence on acceptance at the current acceptable quality level (I1, 7). As a further important point, the degree of immersion—or the *realism* of the applications—was named:

> *"And the more immersive such an experience is, the better, the higher the acceptance, the higher is the learning effect." (I1, Project Team Member in the area of new technologies, Medical Technology Sector)*

Basically, a high degree of immersion was considered beneficial, also because the relation to one's own work was better perceived (I1, 3, 8, 10), and people could identify better with their virtual avatar (I14). However, exceptions were mentioned, e.g., in the medical field, it may not always reasonable and ethically justifiable to expose users to a scenario that is as close to reality as possible, e.g., when a virtually treated patient dies (I3, 8, 10).

The realism was also influenced by the ***haptics***. Appropriate technology, e.g., data gloves, exoskeletons, or the use of real tools that are tracked, could support this. The haptics and sensitivity, which were considered to still be fairly poor, limit the use cases of IVR and therefore the perceived benefit of the technology on the part of the users:

> *"I think it's very important that we have a haptic component. [...] The haptics also provide feedback for the surgeon, who works very finely with his tactile skills. And of course, he misses exactly this level. That's why we are currently only going in the direction of: 'I can only train procedures, or to visualize something that helps me to understand it better'. You can actively operate, but a very important part is missing." (I5, Trainer, Medicine Technology Sector)*

Hygiene played an important role for use in group training, e.g., through regular disinfection of VR glasses or protective masks. One interviewee expressed that there were even reservations in advance as to whether appropriate technical hygiene standards could be maintained in the company (I8). For users to feel **safe** during use and to be able to fully engage with the virtual events, it should be ensured that people do not accidentally bump into objects or walls and cannot trip over the cables (I1, 7, 9, 14).

Social factors were addressed. The respondents were asked to assess the extent to which they feared that the use of IVR could lead to the risk of ***social isolation*** in the future. This was negligible for the majority of the respondents when considering the current state of technology, especially for work-related use. On the contrary, the advantages, e.g., bridging spatial distances, were emphasized (I1, 10). It was highlighted several times that IVR is only seen as a supplement and not as a substitute, and that personal contact should continue to be maintained in the future (see also Section 5.1):

> *"I definitely see social isolation, especially in the gaming industry, when you get lost in these worlds. I am less concerned for the professional use of VR because I see social exchange and VR more as an advantage in scenarios where people would have to travel far to realize a reality meeting. People who are in the same building, or if you are not far away from each other, will probably still choose the personal option. Therefore, in my opinion it is more a medium that bridges long distances and minimizes isolation rather than promoting it. At least in this area. As far as the private area, entertainment, is concerned, I rather worry about it." (I13, Scientific Assistant, Medical Sector)*

Another aspect relates to ***data protection***. IVR offers the possibility to track certain parameters in training, e.g., running distances, errors or time needed. The main goal is to avoid that the participants feel embarrassed in front of the other participants by

summaries, comparisons of results, or errors that are stored. This would negatively influence the acceptance (I3, 9, 15). In ten of the participating organizations, no corresponding data was tracked and stored at the time of the survey. One respondent stated that plans were being made for the future but that these must be in line with the works council and the internal learning management system (I11). Two respondents said that only class-based evaluations were possible at that time but no individual feedback (I1, 9). In addition, as a further influencing factor, one respondent named the fact that people with an HMD could feel uncomfortable because they perform movements in an unfamiliar way in empty space, which could ***look strange*** to the other participants and would thus "make a fool of themselves" in front of the others.

5.5 Novelty effect

Some interviewees reported a "wow effect" of IVR (I1, 2, 3, 13, 14). Especially when using it for the first time, users such as trainers and training participants were surprised and excited about the possibilities. Only one person expected the enthusiasm for IVR to increase if it was used more often (I8). In contrast, the majority of the subjects assumed that this initial enthusiasm for IVR would wear off with more frequent use. Using the technology would no longer be novel but normal. Two respondents (I5, 14) expected that, as long as the actual benefit for the users remained visible, the enthusiasm would remain:

> *"Well, I think that the motivating character etc. will remain. Because it is a really interesting and meaningful medium of education. I think that will remain. But with additional experience and perhaps even if there are several scenarios, and perhaps several types of them, they will be compared. 'Well, this is not as colourful as the last one was' and 'I have already seen better things', and so on. The satisfaction decreases a little bit, because the demands increase with the habit. One can differentiate better, if something is really well done or not." (I14, Head of Educational Media, Transport/Logistics Sector)*

6 Discussion

The present study addressed the question of which factors promote and inhibit the technology acceptance of immersive virtual environments (IVR) in teaching-learning contexts in organizations. Expert interviews were conducted with 15 persons from 13 organizations that used IVR in teaching-learning contexts, such as training. Prerequisites were that the organizations had been using IVR with HMDs in teaching-learning contexts for at least six months and that the person interviewed had experience with IVR. The interviews were evaluated using a structured qualitative content analysis.

Regarding the organization, the trainers, and the training participants, usefulness was confirmed as a decisive factor for individual acceptance and adoption on an organizational level. This result is consistent with the reported study results on IVR [18, 31, 35] as well as the original assumptions of TAM. There must be a recognizable

added value, e. g. in a return on investment for management, through simplified explanations for the trainers or through better learning outcomes for the participants to ensure that the use of the technology in training is profitable in the long term and to encourage participants to use it with pleasure. For the organizations interviewed, this added value currently consists primarily of promoting digitization processes and being able to present themselves effectively in marketing terms. However, this "hype" of using innovative technology is expected to decline as the novelty of the technology wears off [40, 41]. If other benefits are not confirmed by then, it is expected that the use of IVR will not become widely implemented in organizations. Above all, a return on investment still needs to be demonstrated in some organizations.

For the acceptance of the trainers, it seems to be relevant how well IVR can be integrated into (existing) training schemes, what effort is involved, and how reliably it can be used during training. Closely related to this is the usability of the system, especially when it comes to the setup, e.g., when connecting the trackers. Extensive user training and user support are recommended to support the trainers in handling the systems and to reduce initial fears of contact. Usability is also considered relevant for the users, thus supporting the basic assumptions of the TAM. In this context, various technology-related influencing factors were inferred, including aspects of wearing comfort, cable-attachment, haptics, hygiene, and safety. These points provide indications of how IVR must develop technologically in the future to achieve greater acceptance. Regarding personal factors, a fundamental openness to technologies and previous experience with IVR seems to be more important than the age of the users.

The interviewees estimated the acceptance on the part of the trainers and the participants as generally positive, whereby the evaluation of the training participants turned out explicitly positive. Trainers may be more critical of IVR because they recognize a higher effort required to use it, e.g., because their training concept has to be adapted. However, the initial enthusiasm of users for IVR, especially the "wow effect" after first-time use, should not be overestimated [42]. The majority of respondents assumed a novelty effect of the technology, i.e., that the initial enthusiasm will decrease with use [43, 44]. Therefore, the technology must have real added value to maintain a positive assessment and not just be perceived as a gimmick. Since hardly anyone has used IVR as a participant in multiple training sessions, this development must be considered in the longer term. Overall, the use of IVR in the interviewed organizations still seemed to be in a kind of "trial phase". The focus for them was on trial-and-error and gradual "learning by doing". According to their own statements, the organizations had not yet reached an optimal state for the use of IVR and continued to assess the possibilities and limits of the technology in an exploratory process.

Limitations of the study arise with regard to the limited sample of 13 organizations in the German-speaking area. The study does not claim to be representative. In particular, the number of trainers involved was still small. Furthermore only men participated in the study, which limits the diversity of the sample. The participants took part in the study voluntarily, i.e., possibly especially persons with positive experiences with IVR were willing to give an interview. The interviewees were informed that the results would be reported anonymously and that both positive and negative aspects of the use of IVR would be of interest. However, there is a risk that representatives from

organizations in the sense of publicity (see also Section 5.2 Prestige) would prefer to report positive experiences with the technology to put the company in a good light. Finally, due to the qualitative approach and the possibly subjective assessments of the interviewed persons, only limited statements can be made about the strength of the individual influencing factors identified and the degree of acceptance by the trainers and training participants. The frequency with which individual factors were mentioned provides only an initial indication. Further quantitative studies will have to follow.

For future studies, it would be interesting to observe which technological developments IVR will undergo in the next few years and whether some of the currently inhibiting aspects mentioned above can be improved or eliminated. The assumed technology-specific factors should be verified in further quantitative studies with larger and more diverse samples. Since the acceptance of IVR among trainers has only received rudimentary attention so far, this user group should receive more attention in future studies. In conclusion, the empirical findings are in line with the state of research on factors influencing the acceptance of IVR and extend them meaningfully. Organizations that wish to use IVR in teaching-learning contexts can infer concrete recommendations for action from the results, which can increase the probability of a positive acceptance by users. Further quantitative studies should follow on this basis.

7 Acknowledgements

8 References

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9 Author

Carolin Pletz is a research associate at the Department of Vocational Education focused on Teaching Technology (BPT) at the University of Stuttgart, Institute of Educational Science, Azenbergstraße 12, 70174 Stuttgart, Germany. Her research interests are focused on reasonable applications of virtual reality in education, technology acceptance and the transfer of virtual learning.

10 Appendix: Semi-Structured Interview Guide

1. Demographic questions
   (a) How old are you?
   (b) What is your current profession?
2. Use of IVR
   (a) Which IVR hardware and software is used in your company?
   (b) Please describe an IVR training application.
   (c) How are the IVR applications created (internally /externally)?
   (d) How often is IVR currently used in your company in training?
   (e) What experience do you have personally with IVR?
   (f) Who are the users of IVR in training?
   (g) Please describe the setting, i.e., how IVR is used for training.
   (h) What period of use would you recommend for a HMD?
3. Acceptance of IVR
   (a) Why do you use IVR in your company?
      (i) How is IVR useful for your company?
      (ii) What factors would you use to make the decision about, whether IVR is further used in your company or not?
      (iii) Is the use of VR worthwhile from an economic point of view?
   (b) What concerns arose before the implementation of IVR?
   (c) How do the users (training participants vs. trainers) evaluate IVR?
      (i) How do they evaluate the usefulness / ease of use?
      (ii) To what extent is IVR motivating?
      (iii) To what extent does the frequency of use influence the evaluation of IVR?
   (d) What factors influence whether users (training participants vs. trainers) want to use the technology or not?
      (i) What user-related factors do you identify?
         (1) To what extent have you found influences related to age / experience with IVR?
      (ii) What organizational factors do you identify?
         (1) To what extent is there user training / user support / support from the management?
      (iii) What technology-related factors do you identify?
         (1) To what extent do health complaints / motion sickness occur?
         (2) To what extent do you have experience with regard to wearing comfort?
         (3) To what extent do you fear social isolation?
   (e) How does IVR need to develop in the future so that users will use it?
   (f) What factors should be taken into account during implementation of IVR to positively influence user acceptance?

Notes: The original guide was in German. In-depth questions are marked in grey and they were asked when participants did not address these issues themselves.