How Machines are Serviced – Design of a Virtual Reality-based Training System for Technical Customer Services

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Abstract. Training service provider is a crucial factor for high-quality service delivery. Due to the rise of new devices, reviving Virtual Reality (VR) offer great opportunities to overcome current training challenges. As various new interaction and visualization systems push into market, guidance on how to design VR-based training systems is necessary. The presented use case is based on technicians in technical customer services (TCS) who tackle increasing complexity of machines. We fill the research gap of design knowledge by (1) analyzing the domain in a multi-method approach to elicit meta-requirements, (2) proposing design principles, and (3) instantiating them in a prototype. The interaction of the user with the training system was identified as key aspect to foster learning. We follow a design science research approach (DSR) combing the build-phase with agile evaluation cycles obtaining focus groups and demonstration with a prototype.

Keywords: Virtual Reality, Learning, Design Science Research, Technical Customer Services

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1 Introduction

Due to the high range of tasks [1] combined with the increasing complexity of machines [2], service technicians processes of technical customer services (TCS) are complex entities. Thus, training technicians is a crucial factor for high-quality service delivery. It is common to train the relevant skills directly on the job which is time consuming and expensive as the service is completed slower or error costs for mistakes arise. Another option is the use of training facilities but they involve travel expenses, running costs for the facility and time for traveling.

Existing literature proposes the use of Virtual Reality (VR) as it provides a virtualized simulation that suits training purposes well. In addition, the immersion or presence effect of VR enhances the transfer of learned processes to the real world [3]. As VR technology is known for several years some prototypes are presented in literature (e.g. [4]) but the broad usage was, due to their costs, rather limited. With new technology and, especially, new interaction systems the usage in a larger context gets possible, which is why we revive the discussion and propose to use VR while building new training systems. Based on the example of TCS, this allows us to train the service provider (technicians) and generate a better understanding of machines with lower costs than training on the job or training facilities would provide.

The paper makes use of the design science research paradigm and follows its four step approach: (1) for analysis we used a multi-method approach to elicit requirements. (2) Based on them we derived design principles and instantiated the system. (3) We evaluated the artefact multiple times through focus groups during the development and a demonstration (formative), and (4) diffused our insights, which is done with this contribution. The core of this work is the blueprint of a VR-based training system that is based on the elicited requirements and design principles. So, further similar systems can be built analogously to our instantiation. Gregor and Hevner [5] argue that the instantiation itself contributes to the knowledge base.

The paper is structured as follows: First, we introduce the related work of VR in the next section. In section 3, we introduce our research approach. Next, we present the artefact design comprising the meta-requirements, design principles and the instantiation. We conclude by discussing novelty, practical relevance, theoretical contributions, and limitation as well as giving an outlook for future work.

2 Related Work

Virtual reality and so called head mounted displays (HMD) have a long history [6–8]. Up to the last 2-3 years most research made technical possibilities of HMD subject to discussion; only few business-related questions and use cases were discussed [9]. This was due to the fact of high cost of the first HMD systems.

On the basis of new technological developments (e.g. such as the announcement of Oculus Rift) new opportunities arise. New devices are being developed to enhance usability for the user [10]. The three principles of VR *immersion*, *interaction*, and *user* *involvement* with the environment, offers a very high potential in education by making learning more motivating and engaging [10].

Most of the research relates to medical training systems (e.g [10–13]), but also maintenance and service have been discussed (e.g. [14–19]). An example is the work of Rahimian at al. [21] who reports the use of VR for the professional training of architecture, engineering or construction specialists. The authors focus on visualization technologies to foster innovation in engineering [20]. However, the investigation of user interactions with the devices have rarely been discussed as it was not possible with the technologies so far. A close to reality training scenario could be realized only by combining the VR visualization with interaction and tracking of hands to model work steps. This is where our work starts.

Freina and Ott (2015) investigated in their state of the art of VR education several aspects for the main motivation of VR usage: it is mainly used for scenarios that "cannot be accessed physically". This limit may be due to time problems, physical inaccessibility, limits because of a dangerous situation or ethic problems [10]. In line with the authors, we started our research because of the need of maintain objects on machines that are physical inaccessible or just accessible for one technician and not the trainer. An example is the training scenario in the tank of an agricultural machine which is described in the instantiation section.

Guidance for the design of VR systems is suggested by several authors. For instance, Wann [21] took up design principles from a psychological perspective. Further, Chaturvedi et al. [22] propose core properties for building virtual worlds. Kohler et al. [23] suggest key principles such as usability, sociability, pragmatic and collaborative to build virtual worlds. Finally, Sutcliffe and Gault [24] investigated criteria for successful virtual reality applications that are suitable to be basis for design principles. All of them discussed the design in context to older virtual reality devices. Thus, we founded our design principles on them but expanded them to new aspects of new hardware and enhanced interaction components.

3 Research Approach

We follow a design science research (DSR) approach [25–27] as it is generally accepted for service systems engineering (SSE) [28]. Based upon their study about the state of the art in SSE, Böhmann et al. [28] argue, that the complex socio-technical context of service systems restricts the opportunities for meaningful laboratory-style research. Hence, they propose that research needs to be embedded within a service system in a real-world scenario and call for the design of novel service systems. In line with the authors, our approach continuously involves experts from TCS as well as observations of real-world process scenarios. We investigated the four phases analysis, design, evaluation and diffusion. By contributing our work we spread our insights (diffusion); the other three phases (analysis, design, evaluation) are shown in Figure 1.

Once the relevant business problem was defined, according to Hevner [29], attributes of the pursued future system have to be investigated and defined. These attributes are usually referred to as *meta-requirements* [30] because they reflect generic requirements that should be met by the future system (cf. section 4.1). The meta-requirements were elicited from the analysis of the real-world scenario (workshops, process analysis, expert interviews, benefit analysis).

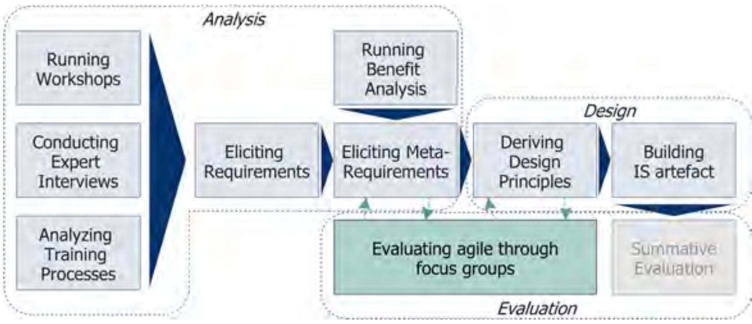

Figure 1. Research Approach

Although VR has a long scientific history, practitioners only have few experiences and just a brief idea about its usage in their specific scenario. This is why we chose to conduct a multi-method approach (workshops, expert interviews, process analysis, benefit analysis), on the one hand, to explorative analyze the domain and combine the different points of view and, on the other hand, calibrate and validate our work [31]. Next, an information system needs to be designed that meets the identified meta-requirements. Therefore, we proposed *design principles* (DPs) that describe how the new system should be built in order to fulfill the identified meta-requirements (cf. section 4.2). Finally, the IT artefact was instantiated (cf. section 4.3).

Since the evaluation of design artefacts and design theories is a central and critical part of DSR [27, 32], we combined the build-phase with several evaluation phases. How to go about choosing and designing an appropriate evaluation approach is a very significant but under-addressed issue in extant DSR literature [33]. Hence, Venable et al. [33] propose a framework for developing an appropriate evaluation strategy. Following their argumentation, our evaluation strategy is human-risk & effectiveness-oriented, due to the novelty of VR in practice. As a result, we have to evaluate our artefact early in a naturalistic setting, conducting formative and summative evaluations [33]. For implementing the evaluation strategy, we made use of agile software development [34] to rapidly develop and evaluate the software continuously (formative evaluation with focus group). So, we were able to validate the applicability to real world problems. The final summative evaluation is not part of this paper (thus, indicated in grey in Figure 1).

3.1 Requirement Collection and Analysis

User Workshops. The collection of requirements started with user workshops (first workshops). The goal was twofold. First, we wanted to get everyone's ideas on how a VR-based training system might look like (brainstorming session). Second, we wanted to collect an initial set of requirements we could start with (collection session). In order to get a broader understanding and minimize bias, we prepared the same workshop twice in two companies of different size and field. Both are part of the machinery and plant engineering sector with a major focus on TCS. The reason of splitting the workshops to different companies with different sizes was to get a company-, sector- and size-independent view. Overall, we had 13 participants from the group of technicians (user), service instructors and the management board.

For the collection of the requirements, which is the relevant part for this paper, we concluded the brainstorming session with an introduction about VR technology, its features, limitations and expectations. Afterwards, we answered everyone's questions before we asked them to write down requirements they have on a VR-based training system on paper cards. Those were put on a poster and consolidated (in case that requirements are mentioned multiple times). When everyone finished the collecting, we discussed the idea connected to every requirement. After everyone was clear, we asked them to rate every requirement (benefit analysis) on a three-tier scale ranging from 1 (very important) over 2 (important) to 3 (not that important). To minimize social influence and further specify the requirements, we asked every participant in the following interviews, as they were done with the same participants, individually what the most important requirements are.

Interviews with Practitioners. We used a semi-structured interview with eight questions separated into a general part and a requirement-specific part. In the general part, we asked questions about demographical information, their experience with VR before we started the workshop, and the general assessment of the technology. The questions were chosen to get an idea about the current situation and the attitude of the interviewee towards VR. Within the requirement-specific part, we asked the interviewee to name the two most important requirements from the workshop and about potential showstoppers that prevent people from using a VR-based training system. To sum up, the interviewee was asked to describe how training is conducted in their company, what challenges they face with the current approach and, finally, whether they think that VR might be beneficial. Regarding the documentation and the analysis procedure of the interview transcripts, the recording technique consisted of a digital record and afterwards a full text transcription and a content analysis [35].

Process Analysis. Besides the use of workshops (including interviews and benefit analysis) the current situation in training was of major importance. Therefore, we attended in multiple trainings in both companies and analyzed how technicians are taught and what role TCS processes play. Making use of shadowing [31] we participated with two IS researchers, tried to minimize our influence and documented the training itself. Afterwards, the transcripts were analyzed regarding the setting and the TCS processes to derive requirements or validate the known requirements.

Meta-Requirements. In order to generate a manageable list out of all mentioned requirements, to start implementing with, we first clustered them using open coding [35]. This was done to ensure that different aspect implied in the requirements are included. Among every clustered group, we chose the requirements that were rated highest in the benefit analysis. For the software implementation three groups were excluded as they target organizational aspects that are not relevant for the software or aspects that are not in focus of a training system. The process of generating meta-requirements was done by a researcher team of three information system researchers. Afterwards, the meta-requirements were discussed with the focus group (as described in 3.3 and appendix A). The remaining list form the (evaluated) meta-requirements that are discussed in the following.

3.2 Implementation

Starting with the elicited meta-requirements, the aforementioned team of information systems researchers derived design principles that support the design of the system. Those were based on a literature study, including papers that explicitly state design principles for Virtual Reality. Based on them the system is likely to fulfill the initial requirements. The derivation itself was executed in iterations to refine and revise the principles over and over again. When the team was convinced the meta-requirements were discussed with the focus group (as described in 3.3 and appendix A) and, thereby, evaluated to cover the most important aspects. Afterwards, the system was implemented in cooperation between the information system researchers and visual technology experts. All features were implemented in an agile approach with integration of the focus group multiple times (evaluating multiple versions of the system). The result of the implementation is described in section 4.3 and gives insights into the VR-based training system.

3.3 Evaluation

Following a human risk & effectiveness evaluation strategy, we conducted several formative evaluation cycles and a final summative evaluation [33]. For the evaluation of the meta-requirements (second workshop) and the design principles (third workshop), in each case we used discussions in form of focus groups [36, 37]. The focus group meetings were conducted in 2015 (For details about the participants see Appendix A). Different types of participants and at least two of every type were invited; on the one hand, to get different point of views, on the other hand, to have people with homogenous background to get a free-flowing conversation [36]:

1. Representing the TCS and, hence, user and customer perspective from practice, three attendees from a medium-sized service provider for air-conditioning technology and three participants from a large agricultural technology manufacturer with own TCS attended.
2. For gaining insights from a technological perspective, two IT practitioners and two visual technology researcher with expertise in implementing VR participated.
3. To bridge the technological and service view, three IS researcher specialized in service science were invited and took up the role as leader of the open discussion.
4. For the design of the content and targeted communication of information, two researchers with specialty in education and media psychology were invited.

So, with the focus group meetings, we were able to evaluate the functional design and usefulness of the VR-based training system in the business context of TCS.

4 Artefact Design

Within this section, we present the design process of our IS artefact. To specify the real world problem, we start with the meta-requirements that were generated. Based on them design principles are presented that deal as foundation of the implementation of our VR-based training system. Additionally, we give details about how our system was designed and how the design principles influenced it.

4.1 Meta-Requirements

Through the multi method-approach, we generated an overall of 69 requirements structured into seven cluster. The clustered groups were named *generating*, *content*, *interaction*, *usage*, *organization*, *output* and *general*. The groups *output*, *organization* and *usage* were excluded as they do not have a training focus but rather an organizational focus. The group *output* contains requirements concerning additional output variants of the system that might be needed in organizations but not for training. The second group *organization* targets organizational aspects that are not relevant for implementation. Finally, the third group *usage* aims at scenarios where the system might be usable besides training. With the remaining four groups 14 meta-requirements are selected that were ranked highest. They are described in the following:

- **MR1: Include CAD-data.** Usually for every machine the manufacturing company owns construction data (named Computer-Aided Design). This three-dimensional model of the machine is designed by engineers for construction purpose, before the machine itself is built. As those CAD-models (mostly) are an accurate representation of the machine, they should be the source VR builds the representation on.
- **MR2: Recording of guided trainings.** The VR-based training system should be based on a guided training that leads the trainee through the process. The trainer should be able to record or prepare trainings on his own.
- **MR3: Highlighting of parts.** As complex machines consist of several parts, the selection and highlighting of parts is beneficial to understand what parts exist and how they are installed.
- **MR4: Assembly of parts.** The system needs to simulate the assembly of parts of the machine to enable the trainee to understand which parts belong to the machine and to see parts lying underneath others.
- **MR5: Disassembly of parts.** Analogously, the disassembly of parts must be included as well to enable maintenance or repair processes.
- **MR6: Movement of parts.** While (dis-)assembling, the trainee should be able to move, rotate and inspect the parts to see and understand the details.
- **MR7: Validated interaction.** To ensure that trainees are learning the correct order on how to (dis-)assemble parts of the machine, the system needs to validate whether the interaction with the parts is possible.
- **MR8: Meta information on parts.** When inspecting or moving the parts, the system should include meta information about the part such as the name or part number.

- **MR9: Variants of machines.** As machines often exist in different variants (e.g. for different markets), the system should include information about different parts and in which variants they are used.
- **MR10: Machine parameters.** The training system should include settings and machine parameters of parts or the machine itself, as they might be crucial for the maintenance and repair.
- **MR11: Tool information.** For certain parts tools are needed (e.g. for fixing or configuring). The training system should include information about tools needed.
- **MR12: Intuitiveness.** For the training the usability plays a major role. The trainee needs fast and easy access to the system without a long training phase for the interaction with the training system itself.
- **MR13: Motivating.** On top of fast and easy interaction, the system needs to be pleasurable to use and motivating. This improves learning performance and trainee's intention to use.
- **MR14: Realistic.** Finally, the system needs to be as realistic as possible to encourage transfer of knowledge acquired in the system to a real world scenario.

Summary. Overall, we elicited 14 meta-requirements based on workshops, expert interviews and benefit analysis. In particular, the interaction with the service object (to simulate a real service scenario) is of major importance (MR3 – MR7). This is why, we explicitly focused on interaction design within our design principles in the next section.

4.2 Design Principles

Starting with the meta-requirements, we derived design principles that support the design of the training system. They are described in the following:

- **DP1: Use existing construction data.** As described, construction data for machine exist in the companies. Thus, the first design principle is to build the system on top of the construction data and integrate various data formats to allow applicability in different companies (as they might use different software for CAD). In addition to the fulfilment of MR1, another minor requirement for easy maintenance of the system benefits when the system is built on top of existing systems and software (compatible to user's domain as proposed by [24] and sustain user-created content (ES3 by [22])).
- **DP2: Integrate process data.** With the need for guided training, the reuse of already existing training processes is suggested and contributes to the principle sustain user-created content (ES3 by [22]). So, the system should be built on top of process models as main representation as they are well understood and explored in literature and practice. This would fulfill MR2 and MR7 (as the interaction can be validated by the process).
- **DP3: Integrate additional parts information.** As there are some requirements concerning information on parts, the system needs to include textual or medial information. So, when the trainee is facing or moving the particular part of the machine it is possible the learn more about it. Thus, the trainee can learn what exactly

the particular part is about. The information ranges from meta information through variants of the machine the part is used in, and parameters of the part to tools that might be needed for the particular part. This fulfills MR8-MR11. The design principle was not present in literature about VR design principles [21–24]. However, it was explicitly asked by the technicians in the workshops and by the education and media psychology researchers in the focus group evaluation.

- **DP4: Carefully design parts interaction.** As different interaction with parts of the machine is needed, this becomes a main aspect of the system. For the training system the interaction is the key feature that enables trainees to understand and learn. Thus, special attention about the way of interacting with the system is crucial (in line with principle 1 by [21] and the usability principle by [23]). The design principle contributes to MR3-MR6.
- **DP5: Reduce interaction possibilities.** Finally, recent interaction systems in VR offer a wide range of pattern (such as controller-based, hand-based, voice-based etc.). However, from the requirements and gained experience the last design principle is, to limit the actually used interaction with the system to one primary approach. This ensures that users are not overwhelmed by different concepts, patterns and interaction approaches. Consequently, this simplifies the familiarization of users with the system. From our point of view, we encourage the usage of hand-recognition-based interaction as it appears to be the most natural way to interact with the system (in line with [24] and [23]). Thus, it fulfills MR12-MR14 as it improves the system's usability, motivation to use and, when hand-recognition is used, the realism of the system.

Summary. Overall, we derived five key design principles. Each of them contributes to at least one meta-requirement. Table 1 summarizes all five design principles and their relation to the meta-requirements and literature.

Table 1. Design Principles

DP	Description	MR	Literature
1	Use existing construction data	1	[24][22]
2	Integrate process data	2,7	[22]
3	Integrate additional parts information	8-11	
4	Carefully design parts interaction	3-6	[21][23]
5	Reduce interaction possibilities	12-14	[24][23]

4.3 Instantiation

The system components (see Figure 2, numbered from 1-3) of the VR-based training system are primarily based on Oculus Rift DK2 (see 1) as a display and tracking device. The tracking captures orientation and position of the head relative to the Oculus Camera. Thus, the interaction in VR are precise and the visualization immersive. For further user interaction, a Leap Motion controller (see 3) is mounted in front of the Oculus head mounted display (HMD). The Leap Motion is a high frame per second hand tracking camera device and gives the opportunity to display hand and motion fluid into the visual experience of the user. To enhance the hand interaction area, a new 30-degree angle mount (see 2) was built to shift the hand area down and support a more natural hand input environment (fulfilling DP4). For the rendering and visual input, a high end gaming computer is needed to realize the necessary power for the experience.

For the visualization pipeline, an own linear learning authoring tool was developed that combined the CAD data (fulfilling DP1) with processes (fulfilling DP2) and results in an immersive VR learning experience. The authoring tool allows using CAD data without ever preprocessing it for the VR environment. On the one hand, the data is not visually optimized to display in VR, but on the other hand, a fast and cost efficient way to create new learning scenarios without touching the CAD data is a big advantage in the creation of lessons.

Figure 2. Hardware component setup

Figure 3. User hand avatar

Figure 4. Placing components

Figure 5. User manual and menu

In the VR-based training system, the whole interface and interaction techniques are mapped to hand gestures and hand movement (see Figure 3). Complex finger tasks are simplified to give the user a better control and robust recognition. The learning tasks are more oriented towards the knowledge transfer than learning certain hand movements (see Figure 4) (fulfilling DP4 and DP5). Additionally, we built a user manual and menu interface (see Figure 5) that comes up as soon as the system detects the inside of the users hand. So, the interaction is twofold: with the out-/upper side of the hand the user can interact with the simulation and on the in-/inner side he or she gets an interface with additional information (fulfilling DP3).

The system is designed for standing users with approximately 2x2m interaction space. Due to the need of a high end gaming computer and the amount of components it is best used in an (mostly) immobile setup.

5 Conclusion, Discussion and Outlook

Conclusion. The effective use of Virtual Reality (VR) offers great opportunities to overcome current challenges in the domain of TCS. Due to the complexity of service systems engineering [28], guidance on how to design service support systems is necessary. To overcome this complexity and fill the research gap of design knowledge on VR-based training systems, we followed a DSR approach within this paper through, first, exploring the domain and eliciting meta-requirements (step 1), and second, deriving design principles continuously working in an interdisciplinary team of practitioners and researchers (step 2). The key feature was the design of the interaction with the service object, as it was the major requirement (to simulate a real service scenario).

Discussion. Before we started the project on VR, our main expectation was that for users the most important requirements would concern the acceptance of the VR device itself. We thought of motion sickness, refusal of wearing the device on the head or problems with spectacle wearers. Surprisingly, the most important requirements we found was about the interaction with the system. So, for our users the VR itself seems to be acceptable straight away as major companies (e.g. Facebook, Sony, HTC) are pushing into market. So, users get more and more in contact with the technology and used to the idea of virtual worlds. We experienced broad interest through all companies and individuals we talked to. Most of them mentioned deployment scenarios in their own processes that might be useful (e.g. constructors (teaching order of assembly), engineers (visualizing unbuilt machines), farmers (introduction and commissioning to tractors)). We further found scenarios that are not trainable without VR, due to danger-related (e.g. the repair of running wheel gears; to build an understanding about what happens when certain gears are damaged) or size-related reasons (e.g. the repair of parts inside of a tank of a spraying machine that is just the size of one person).

Not only because of the broad interest, one main aspect we found was that integration of potential users in development is very crucial. New technologies are connected to a learning process on both sides, developer and user, which is why they have to talk about possibilities and see what works for them and what does not. This is how we came up with integrating a gesture interaction component to offer the hand-based interaction as it was the most natural option for users.

Finally, the VR-based training is suitable at least to teach scenarios that are not trainable otherwise. Whether it might help in other scenarios as well and improve the training is a research question that arose during the project for further investigation.

Novelty and Practical Relevance. We address a real-world problem consisting of need for TCS support through training systems that teach complex machines. At the same time, since recent VR is still an emerging technology, little knowledge about the design of training systems exist. Both from the point of practice and from theory, a transfer of the proposed design knowledge to other user groups or even customers offer new subjects of research. Thus, we formulated the design principles to be as generic and applicable as possible to other user groups and sectors. With our instantiation we demonstrated how to build a VR-based training system using recent hardware (Oculus Rift DK2 and Leap Motion). Hence, cost-efficient training with commercial VR technology is possible, which is of major relevance for small and medium sized companies.

Theoretical Contribution. Regarding the theoretical contribution, this research work contributes to the methodological knowledge base of IS Design and service systems engineering, and builds upon existing methods of DSR and the design of service systems. In DSR, a theoretical contribution is usually regarded to be in form of prescribing how a specific solution can be designed in order to solve a relevant real-world problem; often presented in form of design principles [38, 39] that guide the implementation of specific instantiations. Gregor and Hevner [5] argue that the instantiation itself contributes to the knowledge base as the demonstration of a novel artefact can be a research contribution that embodies design yet to be articulated, formalized, and fully understood. Prescriptive knowledge can be generated through (1) inventing new solutions for new problems, (2) improving and thereby developing new solutions for existing problems, or (3) adopting known solutions to solve new problems [5]. We position our work as a new solution, a VR-based training system, to solve an existing problem consisting of complex machines that needs to be serviced by TCS. We build our work on the knowledge base of Virtual Reality Design Principles. However, for the field of technical customer service the integration of additional service related information and the design of the interaction with the service object is crucial. Thus, we enhanced the known principles with our study. Therefore, we explored the problem domain and formulated meta-requirements that represent the conditions that should be met by a VR trainings solution. Additionally, we contribute to the IS research knowledge base by instantiating the evaluation strategy proposed by Venable et al. [33] in combination with agile software development as enhancement of the classic DSR approach. Hence, with our work, developed in a transdisciplinary team obtaining IS research, service science, education and media psychology as well as practitioners from service providers, manufacturers and IT companies, we meet a research gap and the claim for evidence-based design research [28].

Limitations and Outlook. We discussed our work with experts from two different sectors in order to transfer the design principles to other sectors. However, researchers are welcome to evaluate the applicability and potentially needed adoption separately as the VR-based training system has a wide area of possible applications. Based on the results of the benefit analysis, we focused on an excerpt of all collected requirements and the evaluation of the VR-based training system with technicians. Hence, (1) the transfer of additional requirements have to be investigated further. (2) We have not conducted a summative evaluation regarding the economic benefit and the training success yet. Thus, the next step of our research is the evaluation of our instantiation in form of a field test [40] in the TCS of the agricultural technology company and the service provider for air-conditioning technology. Thereby, an experiment that allows conclusions about the training effect is needed. To sum up, our approach can be considered as VR with new hardware that might lead research to specify new business models or training options.

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References

1. Baines, T., Lightfoot, H., Smart, P., Fletcher, S.: Servitization of manufacture - Exploring the deployment and skills of people critical to the delivery of advanced services. Journal of Manufacturing Technology Management. 24, 637–646 (2013)
2. Däuble, G., Özcan, D., Niemöller, C., Fellmann, M., Nüttgens, M.: Design of User-Oriented Mobile Service Support Systems - Analyzing the Eligibility of a Use Case Catalog to Guide System Development. In: Thomas, O. and Teuteberg, F. (eds.) 12. Internationale Tagung Wirtschaftsinformatik (WI 2015). 149–163. Osnabrück (2015)
3. Regenbrecht, H.T., Schubert, T.W., Friedmann, F.: Measuring the sense of presence and its relations to fear of heights in virtual environments. International Journal of Human-Computer Interaction. 10, 233–249 (1998)
4. Seymour, N.E., Gallagher, A.G., Roman, S.A., O'Brien, M.K., Bansal, V.K., Andersen, D.K., Satava, R.M.: Virtual reality training improves operating room performance: results of a randomized, double-blinded study. Annals of surgery. 236, 458–463 (2002)
5. Gregor, S., Hevner, A.R.: Positioning and Presenting Design Science Research for Maximum Impact. Management Information Systems Quarterly. 37, 337–355 (2013)
6. Rheingold, H.: Virtual Reality: Exploring the Brave New Technologies. Simon & Schuster Adult Publishing Group (1991)
7. Caudell, T.P., Mizell, D.W.: Augmented reality: an application of heads-up display technology to manual manufacturing processes. In: Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences, 1992. 659–669 vol.2 (1992)
8. Sutherland, I.E.: A head-mounted three dimensional display. In: Proceedings of the December 9-11, fall joint computer conference, part I. 757–764. ACM, NY, USA (1968)
9. Teuteberg, F.: Mobile Augmented Reality aus betriebswirtschaftlicher Sicht. HMD - Praxis der Wirtschaftsinformatik, Mobile Anwendungen. 42, 86–94 (2005)
10. Freina, L., Ott, M.: A literature review on immersive virtual reality in education: state of the art and perspectives. In: The International Scientific Conference eLearning and Software for Education. p. 133 (2015)
11. Faria, J. de, Teixeira, M.: Virtual and stereoscopic anatomy: when virtual reality meets medical education. Journal of neurosurgery (2016)

12. Aïm, F., Lonjon, G., Hannouche, D., Nizard, R.: Effectiveness of Virtual Reality Training in Orthopaedic Surgery. The Journal of Arthroscopy (2016)
13. Huang, H., Liaw, S., Lai, C.: Exploring learner acceptance of the use of virtual reality in medical education: A case study of desktop and projection-based display systems. Interactive Learning Environments (2016)
14. Webel, S., Bockholt, U., Engelke, T., Gavish, N., Olbrich, M., Preusche, C.: An augmented reality training platform for assembly and maintenance skills. Robotics and Autonomous Systems. 61, 398–403 (2013)
15. Westerfield, G., Mitrovic, A., Billinghurst, M.: Intelligent Augmented Reality Training for Assembly Tasks. Artificial Intelligence in Education. 542–551 (2013)
16. Seth, A., Vance, J.M., Oliver, J.H.: Virtual reality for assembly methods prototyping: a review. Virtual Reality. 15, 5–20 (2010)
17. Gavish, N., Gutierrez, T.: Design guidelines for the development of virtual reality and augmented reality training systems for maintenance and assembly tasks. BIO Web of Conferences. 29, 1–4 (2011)
18. Yuviler-Gavish, N., Krupenia, S., Gopher, D.: Task Analysis for Developing Maintenance and Assembly VR Training Simulators. Ergonomics in Design: The Quarterly of Human Factors Applications. 21, 12–19 (2013)
19. Woll, R., Damerau, T., Wrasse, K., Stark, R.: Augmented reality in a serious game for manual assembly processes. 37–39 (2011)
20. Pour Rahimian, F., Arciszewski, T., Goulding, J.: Successful education for AEC professionals: case study of applying immersive game-like virtual reality interfaces. Visualization in Engineering. 2, 4 (2014)
21. Wann, J., Mon-Williams, M.: What does virtual reality NEED?: human factors issues in the design of three-dimensional computer environments. International Journal of Human-Computer Studies. 44, 829–847 (1996)
22. Chaturvedi, A.R., Dolk, D.R., Drnevich, P.L.: Design Principles for Virtual Worlds. 35, 673–684 (2011)
23. Kohler, T., Fueller, J., Matzler, K., Stieger, D., Füller, J., Matzler, K., Stieger, D.: Co-creation in virtual worlds: The design of the user experience. MIS Quarterly. 35, 773–788 (2011)
24. Sutcliffe, A., Gault, B.: Heuristic evaluation of virtual reality applications. Interacting with Computers. 16, 831–849 (2004)
25. Peffers, K., Tuunanen, T., Rothenberger, M. a., Chatterjee, S.: A Design Science Research Methodology for Information Systems Research. Journal of Management Information Systems. 24, 45–77 (2007)
26. Österle, H., Becker, J., Frank, U., Hess, T., Karagiannis, D., Krcmar, H., Loos, P., Mertens, P., Oberweis, A., Sinz, E.J.: Memorandum on design-oriented information systems research. European Journal of Information Systems. 20, 7–10 (2011)
27. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design science in information systems research. MIS Quarterly. 28, 75–105 (2004)
28. Böhmann, T., Leimeister, J.M., Möslein, K.: Service Systems Engineering. Business & Information Systems Engineering. 6, 73–79 (2014)
29. Hevner, A.R.: A Three Cycle View of Design Science Research. Scandinavian Journal of Information Systems. 19, 87–92 (2007)
30. Walls, J.G., Widmeyer, G.R., El Sawy, O. a: Assessing information system design theory in perspective: How useful was our 1992 initial rendition. Journal of Information Technology Theory & Application. 6, 43–58 (2004)

31. Myers, M.: Qualitative Research in Business & Management. Sage Publications Ltd., London (2009)
32. March, S.T., Smith, G.F.: Design and natural science research on information technology. Decision Support Systems. 15, 251–266 (1995)
33. Venable, J., Pries-heje, J., Baskerville, R.: FEDS: a Framework for Evaluation in Design Science Research. European Journal of Information Systems. 1–13 (2014)
34. Beck, K., Beedle, M., van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., Jeffries, R., Kern, J., Marick, B., Martin, R.C., Mellor, S., Schwaber, K., Sutherland, J., Thomas, D.: Manifesto for Agile Software Development, http://agilemanifesto.org/, (2001)
35. Mayring, P.: Qualitative Inhaltsanalyse Grundlagen und Techniken. Beltz, Weinheim (2010)
36. Morgan, D.L.: Focus Groups as Qualitative Research. SAGE Publications (1996)
37. Krueger, R.A., Casey, M.A.: Focus Groups: A Practical Guide for Applied Research. SAGE Publications (2014)
38. Kuechler, W., Vaishnavi, V.: A Framework for Theory Development in Design Science Research: Multiple Perspectives Science Research. Journal of the Association for Information Systems. 13, 395–423 (2012)
39. Sein, M.K., Henfridsson, O., Rossi, M., Lindgren, R.: Action Design Research. MIS Quarterly. 35, 37–56 (2011)
40. Sonnenberg, C., vom Brocke, J.: Evaluations in the Science of the Artificial - Reconsidering the Build-Evaluate Pattern in Design Science Research. DESRIST 2012, LNCS 7286. 381–397 (2012)

Table 2. Appendix A: Workshop participants

#	*Position*	*Sector*	*Experience in position*	*Size of the company*
1	Research assistant	University, Information Systems	3 years	~ 1.700
2	Research assistant	University, Information Systems	3 years	~ 1.700
3	Professor	University, Information Systems	7 years	~ 1.700
4	Managing director	Service provider for air-conditioning	> 20 years	~ 240
5	Assistant to the board of directors	Service provider for air-conditioning	2 years	~ 240
6	Assistant to the board of directors	Service provider for air-conditioning	4 years	~ 240
7	Research assistant	Application-oriented research, Visual Technology (VR expert)	1 year	~ 560
8	Researcher, Head of Visual Technology	Application-oriented research, Visual Technology (VR expert)	> 10 years	~ 560
9	Service trainer	Agricultural technology	> 10 years	~ 1.800
10	Team Assistant After Sales	Agricultural technology	1 year	~ 1.800
11	Head of After Sales	Agricultural technology	> 20 years	~ 1.800
12	Researcher	University, Education and Media Psychology	> 20 years	~ 2.800
13	Professor	University, Education and Media Psychology	> 20 years	~ 2.800
14	IT expert	IT company, Learning Technologies	5 years	~ 220
15	IT expert	IT company, Learning Technologies	1 year	~ 220