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Ready Designer One: Exploring Expected Conditions for Interrupting Design Work by Virtual Reality

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READY DESIGNER ONE: EXPLORING EXPECTED CONDITIONS FOR INTERRUPTING DESIGN WORK BY VIRTUAL REALITY

Research Paper

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Abstract

Future forms of work are changing human behaviour and require the embedding of new technologies such as virtual reality (VR). These technologies can affect existing work processes in their original sequence. There is already research on interruptions in the work context that shows negative effects on human behaviour. But what if the interruptions are intentionally built into a process designed to support the designers' work? This research investigates how technically induced hybrid interruptions affect computer-aided design processes through VR. To that end, a VR-based activity was developed, and 17 staff members were surveyed about their engagement with it. This provided insights into how hybrid interruptions can be perceived and under which conditions VR-induced hybrid interruptions are beneficial. Advantages may lie, for example, in process quality. Thus, we contribute to research by providing a broader understanding of interruptions and supporting organizations to consider the identified influencing conditions in their processes.

Keywords: Interruption, Virtual reality, Computer-Aided Design, Digital transformation.

1 Introduction

Digital transformation of business processes enables the balancing act between realistic evaluation and occupational safety. By using new simulation technologies such as Virtual Reality (VR) or Augmented Reality (AR), the model of a machine can be viewed in a three-dimensional (3D) environment in real dimensions (Dangelmaier et al., 2005). Of course, simulations are influenced by the accuracy of the model, and they require some abstractions of the model. However, they also allow focusing on processes such as maintenance. This enables the designer to evaluate already in the design process whether all components are accessible in case of maintenance. If maintenance is not considered from the beginning, maintenance personnel will have a hard time in the long run, e.g., because the designers simply do not know how the machine is maintained. So, if the designers get a sense of how their machine will be maintained, they will design it differently. To achieve this, designers need to empathize with the perspective of maintenance personnel (Kohn and Harborth, 2018). In the best case, the designer could revise the design and thus increase the ease of maintenance and overall work safety of the service employees. Therefore, this research proposed to combine the traditional work of designers at a Computer-Aided Design (CAD) workstation with the evaluation of CAD data in a virtual environment. VR as an extension for CAD modelling is already practiced in some organizations and theoretically researched (e.g., Whyte et al., 2000). When changing existing workflows in this way, it is important to consider whether this will bring only benefits or also negative effects. A negative effect could be that

designers feel disturbed by changing their working environments. When there is a switch between work environments, we speak of an interruption in the work process.

Interruptions are a ubiquitous phenomenon in a digitalized work environment (Jett and George, 2003; A. Chen and Karahanna, 2018). They are defined as "temporary suspensions of an individual's primary task activities in order to process information that is delivered by different media" (Addas and Pinsonneault, 2018, p. 1099). Interruptions are part of our daily life characterized by a primary activity being interrupted by a secondary one (Puranik et al., 2020). After finishing the secondary activity, the attention is returned to the primary one. However, research indicates different forms of interruptions that have a different impact on the interrupted person (Addas and Pinsonneault, 2015). For our research, we refer to hybrid interruptions since they fit with the intended purpose of VR as an interruption in the CAD work process. Interruptions have been predominantly described in a negative manner, as they disrupt or distract workers from their actual work process (Tams et al., 2020). In the course of the digital transformation, the use of innovative technologies is increasingly finding its way into existing work processes (Rodriguez-Lluesma et al., 2021). Here a successful integration that offers a beneficial impact on the worker's task is essential. Nevertheless, by integrating innovative technologies (i.e., VR), organizations do not completely supplement existing processes if these are based primarily on conventional technology (i.e., CAD workstation) and cannot cover the full range of functions. This means that it can be assumed that existing processes will be interrupted in their actual flow through the integration of innovative technologies which results in a temporary lag of the working task. Since interruptions deliver a reason for changing work episodes (Wajcman and Rose, 2011), it is necessary to investigate what potential influencing factors exist in the use of VR with the CAD work process and how they affect the user's perception of this work process.

In summary, designers are more motivated by using innovative technologies that add perceived value to work processes. VR can provide additional support to the design process in the CAD environment and can be used to evaluate CAD data. Under certain conditions, it can have a positive impact on the CAD process and provide useful feedback that supports the process in general. Therefore, we consider VR use during the design process as an extension of the work tasks that interrupt the process. Considering the theoretical construct of hybrid interruption, we aim to investigate factors that make the experience of VR use during the CAD process less disruptive. Based on our assumptions, this paper examines the impact of new technologies (i.e., VR) on traditional, established work processes (i.e., the CAD process), answering the following research question (RQ):

RQ: How can VR approaches be seamlessly integrated into traditional processes such as CAD work to support and enhance these processes?

2 Related Work

2.1 Virtual Reality

Current technological trends provide insight into the opportunities offered by VR. For CAD, especially with a focus on the simulation of processes, VR can offer great benefits. Immersive VR requires a complex interface (e.g., a head-mounted display) and offers the user a 3D experience within a virtual environment that is closed off by VR glasses (Schultze, 2010). Another feature of current VR technology is the provision of controllers for the interaction with and manipulation of objects. These objects can be displayed with a very high level of detail as well as individual process steps. Furthermore, a closed VR environment enables a focused interactive experience (Martín-Gutiérrez et al., 2017).

VR technologies offer potentials for the improvement of work processes that go beyond the possibilities of 3D desktop representations. Research examples are applications for education and training (Kampling, 2018), perspective taking (O Riordan et al., 2012), or simulation of buildings (Hofma and Constantiou, 2018). Common to all these examples is that the existing working knowledge is extended by transferring previous work content into a VR experience, resulting in a better understanding of the content and tasks (Barata and da Cunha, 2019). However, not every workplace is suited to be supported

with VR: The use of VR in the working context requires a concept and a clearly modelled working process. On the one hand, the processes have to be suitable for the application of VR technology. On the other hand, the implementation of VR in existing processes requires the necessary space or a rethinking of the office design since VR requires more space to execute movements than traditional office work. (e.g., Castilla et al., 2013; Coburn et al., 2017). Therefore, the implementation of VR in the work context has not yet been broadly adopted.

2.2 Technology-Induced Interruptions of Working Tasks

In today's world, technology-induced interruptions are a ubiquitous phenomenon. According to Coraggio (1990), interruptions are defined as a break of primary task continuity that captures the cognitive attention on a secondary one. In the context of Information Systems (IS) research, interruptions are concerned as technology-induced interruptions (Tams et al., 2018), and are defined as "a subset of work interruptions where technology creates the interruption (e.g. system failure) or mediates a human-created interruption (e.g. email; SMS; instant messaging)" (Addas and Pinsonneault, 2015, p. 233). Thereby work interruptions "are temporary suspensions of an individual's primary task activities in order to process information that is delivered by different media" (Addas and Pinsonneault, 2018, p. 1099) in work environments and are mostly concerned with negative implications. Due to the great implementation of various technologies for task accomplishment in work conditions, interruptions become ubiquitous and thus problematic by "exposing employees to an endless stream" (Tams et al., 2020, p. 1) of messages, notifications, and reminders. Diverse devices continually "beep, buzz, and blink" (Tams, 2017, p. 5660) and therefore impair the current task performance. The effect on performance varies. However, the results are alarming. While, every five minutes e-mails interrupt office workers, resulting in up to 70 interruptions per day (Addas and Pinsonneault, 2015), other research shows a loss of one-third of the workday (Spira and Feintuch, 2015; Tams, 2017). Regarding those differences, we argue that the number depends on the profession and the integration of technology into the daily work routine.

Interruptions vary in their nature and thus are a complex construct. First, they are other-initiated or self-initiated (A. J. Chen and Karahanna, 2011). Thereby, the environment of the interrupted individual is decisive. On the one hand, interruptions result from an external stimulus and are other initiated. Particularly in the work context, triggered by email notifications, phone calls, or visits from co-workers, interruptions arise from the external environment that shifts attention between different tasks. (Wang et al., 2014). On the other hand, interruptions are self-initiated and occur from the individual's mind (A. J. Chen and Karahanna, 2011), for example by recalling unfinished work (Kalgotra et al., 2017).

Second, the content of the interruption is decisive for the performance impact on the current task (Basoglu and Fuller, 2008). IS research provides a distinction between three stages and distinguishes between interventions, intrusions, and hybrid interruptions (Addas and Pinsonneault, 2015). Interventions are described as secondary tasks that are related to a primary task. They provide information for a current project and are indicated as relevant to primary task performance. Intrusions are described as tasks outside the project portfolio and are irrelevant for primary task performance, whereas hybrid interruptions are described as a mix of both. "They are partly intrusions because they divert attention from the focal primary tasks and partly interventions because they focus attention on other core areas of the individual's project portfolio" (Addas and Pinsonneault, 2015, p. 257). The unique aspect of this type of interruption is that despite the shift of focus, performance can be improved. The content of a hybrid interruption creates feedback that can be imported into the primary task or other portfolio-related projects and therefore affect their performance (Addas and Pinsonneault, 2015). Third, temporal interaction as an additional factor is needed. On one side, interruptions demand an individual's attention immediately to interact with a secondary task and on the other side, interruptions allow the worker to decide when or whether to interact with the interruption task (Tan and Richardson, 2011).

However, despite this background, "[c]ommon to all interruptions is the idea that they force the individual to switch tasks for certain amount of time" (Basoglu and Fuller, 2008, p. 4). Therefore, they follow a certain process. Initially, a primary task is performed. During its performance, a signal or stimuli initiates the interruption as a secondary task. The individual's attention switches from the

primary task, which causes the processing of the secondary one. The switch between the tasks is called interruption lag (Trafton et al., 2003). After processing the secondary task, the primary one is restarted, within the resumption lag (Trafton et al., 2003). Subsequently, the primary task is processed further.

2.3 Research Concept

According to the theoretical background, our research refers to the concept of interruptions, caused by VR usage. We assume that through digital transformation traditional work processes will be expanded with new technologies and thus will be interrupted in their usual flow. The interruption (i.e., VR usage) does not disrupt the work process (i.e., CAD) unnecessarily but complements it with an additional activity. Therefore, we refer at the first step to interruptions in the work context. While research often defines interruptions "as the factors that affect the productivity, lose focus, and work is affected, become an obstacle, additional load, people created groups, disruptions, distract and disturb business" (Jaafar et al., 2019, p. 6) and highlights the negative nature, our research applies to the perspective of Wajcman and Rose (2011). Accordingly, we consider interruptions as "the reason why the […] [designers] changed their work episode" (Wajcman and Rose, 2011, p. 946), which are caused by the improvement of the design process due to VR usage.

At the second step, we adapted the process of interruptions (Trafton et al., 2003; Sasangohar et al., 2013) to the design process (Figure 1). By doing so, the CAD process is regarded as the primary task and the VR usage as the secondary task. Additionally, interruption and resumption lag are considered as technology changes between both media. A change between the design process by CAD work and VR and vice versa. This change during the process represents the lag and indicates, combined with the VR usage, an interruption of the traditional design process on a CAD workstation. Thus, the theories could be transferred to a practical application, which can now be evaluated to gain new insights.

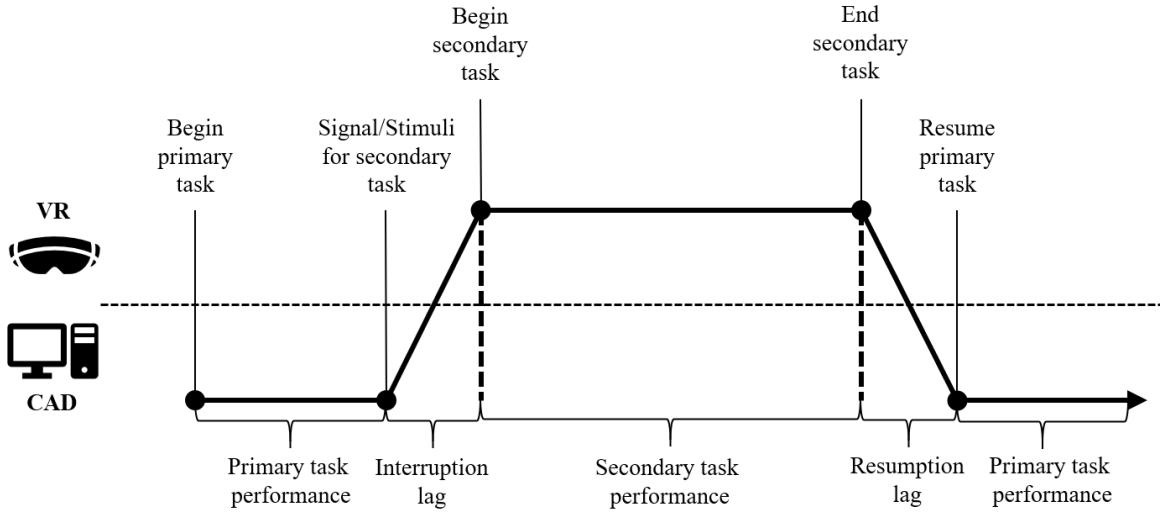

Figure 1. Interruption process (Modified from Andreasson et al., 2017).

At the third step, hybrid interruptions are addressed. Due to their definition as a mixed form, "its content needs to focus on tasks other than the focal primary task, but it must also provide feedback that can be imported by individuals back into the primary task or to other tasks that fall within their project portfolio" (Addas and Pinsonneault, 2015, p. 258). As we assume, using VR during the design process interrupts the process in its initial procedure, but by taking a different perspective (i.e., viewing a CAD model in a virtual environment) valuable feedback is provided that enriches the whole process as an extension to the traditional CAD modelling. Using VR during the process provides valuable feedback due to the consideration of the model in a virtually created environment, which depicts the real one. Therefore, hybrid interruptions provide the right context to underpin our approach. With their duality, they indicate the versatile effect of interruptions and an impact on focal task, focal project, and other

projects in the project portfolio (Addas and Pinsonneault, 2015). As the design process is interrupted by VR usage as a process extension, it provides added value for designing. In addition to the focal CAD model, it can be expected that the gain of information also supports future designs in current and further projects.

3 Methodology

3.1 Application Example

The traditional work process of design-related employees in a desktop design program represents the initial situation of our application example. The design processes of the interviewed employees are currently carried out to a large extent exclusively in 2D. The traditional screen work enables to view their work in 3D, but the possibility to view the construction in real size is missing. 3D desktop visualization reaches its limits for designs that will later have effects on maintenance, appearance, or proportions (Bouchlaghem et al., 2005). Here, VR can extend this view to realistic representations and enables interaction with the model at its later location in its real dimensions. Against this background, VR has the potential to extend the design process in an experienceable way. To create possible synergy effects between traditional desktop design work and the use of VR, the task is to examine in which way VR should be used to enlarge the existing design process (Figure 2). The focus is on observing the extent to which the VR experience used is perceived as a potential interruption.

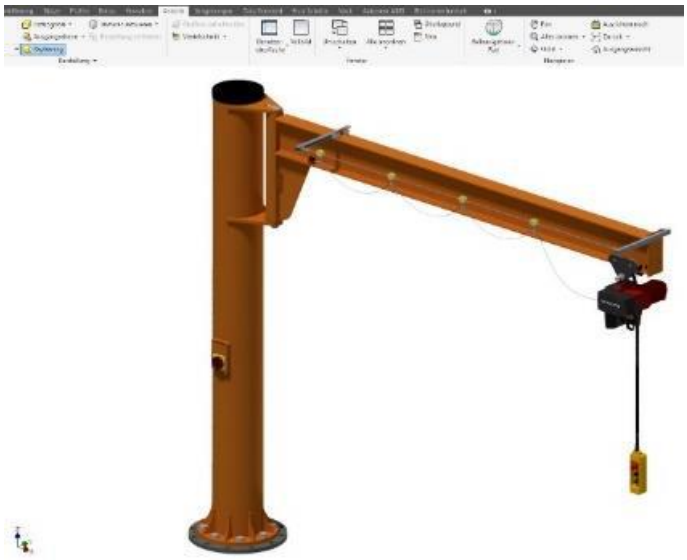

Figure 2. Screenshot of the CAD application

Using VR to evaluate a CAD model can be described as an interruption in the CAD modelling process. Employee's attention shifts from the primary task (i.e., CAD modelling on a workstation) to the secondary task (i.e., VR usage), while both contribute to successful modelling. With the completion of the VR usage, the designer returns to the CAD modelling process and revises their CAD model with the experiences they made in the VR environment. Therefore, the VR supports the process with a closer examination of the CAD model but interrupts the initial CAD process as traditional design work. In our study, we do not examine the interruption process itself but rather the use of VR as an enlargement of the work process and whether it represents a negative or positive interruption from the participants' perspective.

The 17 participants in this study are selected from the staff of a German medium-sized organization that employs about 190 people in the development, production, and sale of cranes. This diversity of position,

gender, work experience, and age were deliberately chosen to represent the entire organization as well as possible. Details of the selected interviews can be found in Table 1.

No.	Position	Professional background	Gender	Work exp. (in years)	Age
1	Design employee	IT staff	m	2	28
2	Technical manager	Mechanical engineering	m	16	43
3	Design employee	Graphic designer	m	25	43
4	Design employee	IT staff	m	9	33
5	Design employee	Sales	m	8	28
6	Design employee	IT staff	m	1	20
7	Technical engineer	Technical draughtsman	m	4	33
8	IT manager	IT staff	m	12	34
9	Design employee	Purchaser	m	3	30
10	Technical engineer	Technical draughtswomen	w	2	26
11	Technical engineer	Technical draughtsman	m	8	38
12	Design employee	Graphic designer	w	2	32
13	Technical engineer	Technical draughtsman	m	8	26
14	Technical engineer	Dispatcher	m	23	50
15	Service fitter	Electrician	m	3	25
16	Trainee IT	Trainee IT	m	3	25
17	Trainee IT	Trainee IT	w	4	27

Table 1. Overview of the interviews.

3.2 Research Approach

The VR application was developed as a prototype with the Unreal Engine. As VR device the HTC Vive Pro was used. Within the VR application, it is possible to build the product (i.e., crane) completely virtually, starting by fixing it on the ground and ending by testing its functionalities. In addition, maintenance steps can be performed virtually. This enables the designers to evaluate their crane design from a service perspective. The models of the products used in the VR environment are created from the organization's CAD data. This made it possible to achieve a virtual detailed representation of the CAD models in a fictitious environment.

At the beginning of the experiment, participants received a brief introduction to VR technology. Afterward, participants were plugged into the VR. Here, the participants were confronted with a VR environment in a warehouse in which they could judge a crane design for ease of assembly. This assessment was achieved because the participants had to perform the assembly steps in VR themselves. The participants were able to drill holes, tighten screws, and carry out the electrical wiring themselves (Figure 3). After completing these tasks, a short interview was conducted according to a semi-structured interview guide. The semi-structured interview guide was chosen to help participants understand the context of the interruption and the potential impact on their previous work process as well as to engage participants in the VR application development and process change. Based on the literature research, the research results on interruption were identified as relevant for our study.

Figure 3. Screenshots from the VR application.

For coding and analysing a qualitative content analysis was applied (Mayring, 2010) with the main objective to identify patterns in the interviews that revolve around the potential interruptions. We wanted to learn more about how the interruption is experienced, and how this affects CAD work. To do this, we used an open coding approach. Therefore, interviews were coded independently by two researchers and discussed together afterward. For example, it happened that the text passage "You have to be open-minded towards the technology of course." Interview 2 was coded as "innovation willingness" by one researcher and as "readiness for innovation" by another researcher. Such conflicts were resolved as one of the existing codes was identified as the best, or the two codes were merged into one. This was repeated until all text passages were successfully coded and both researchers agreed on the result. In the example mentioned, the researchers agreed that the code "innovation willingness" best matched.

These codes were then grouped by topic. In the case of the present example, the text passage was assigned to the parent item "user". These higher-level items were later further grouped into "enables enhanced understanding", "technology switch" and "user-related factors." In case of disagreement among the researchers, a researcher not involved in the coding was brought in for discussion, and a code was determined.

4 Findings

4.1 Enabled Expanded Understanding

Employees see a general advantage in the VR visualization of CAD data. The possibility of evaluating in a virtual environment enables an **understanding of the real environmental conditions**. They can view the designed models more closely and adapt them to the respective environment. This allows a detailed view of certain components and their adaptation (e.g., to their size).

"I could actually imagine the representation in VR being helpful because you don't have that form of experience now. The CAD models lack the reference to the environment. It becomes a bit more complicated, but I think that would be more pleasant in VR." Interview 1

"In a CAD system, you take an assembly or a component and simply place it in the CAD room. You don't have these difficulties that arise due to the conditions in the actual room at the customer's site." Interview 13

Even departments where 3D models are not common (e.g., electrical design) will certainly benefit from using a VR perspective. Currently, only 2D-drawings schematics are used here. However, one interviewee was aware that in the future, VR will enable him to evaluate the components through an **improved understanding of scale**. This will lead to an improvement in object placement, which will support the overall design process.

"We work a lot with 2D drawings, of course in the newer area also with 3D but what we get as an order is mostly 2D, so sometimes you think for a long time, how exactly should it look like. Also, how it is arranged on top of each other in some things, like when you have a power supply, limit switches, […] that can be helpful if you can look at it in VR." Interview 11

"I would be very happy if I could see what I created in the CAD system in VR. That gives me a feeling for things that I haven't seen before." Interview 3

It becomes clear that the use of VR technology within the design process is perceived as beneficial. Interviewee 7 noted that even if a model is designed and can be suitably put into practice, there may be occasional problems regarding the fitting. A premature assessment or execution of the fitting work within VR is therefore seen as a chance for adaptation and error correction.

"You construct something, and in the end, everything fits, but in practice, it is often different and sometimes there are also things that have to do with the assembly. If you have the possibility to play through or replay the montage at this stage, then you could perhaps design differently, in any case. But that depends on the level of detail." Interview 7

"I think it's good in VR when I think about checking something during construction. That's not possible now, because the construction is finished at some point and is then produced, and then you assemble it once. In VR, you can then just look at how these parts can be assembled right now. That is simply much easier to follow in the design. So, you have things, you've built a prototype and then you're guaranteed to change something on it again because some things then stand out in the assembly. That could also save VR a lot of money." Interview 14

Incorporating VR into the design process allows the design to be reviewed for the ease of maintenance. The VR, therefore, enlarges the design process by offering an increased **understanding of potential issues regarding the maintenance.** Using VR is seen as a possibility to enhance the design process sustainably and to prevent avoidable disturbances in advance.

"For example, you have a type of crane and now you have to construct something and then check the accessibility for the fitter, […] then you can, of course, reproduce this directly in such an environment and then see directly where you have faults or collisions or perhaps areas where you cannot reach directly and you can see that very quickly, you don't have that if you don't have that possibility." Interview 7

A positive effect of VR can be identified as the overall attitude of the interviewees. The recognition of a benefit is the focus of the interview findings. Thus, the aspects of job enlargement and a positively behaving hybrid interruption can be substantiated. Designers can react to design hybrid interruptions of their CAD model by using VR, integrated into their design process. The perspective of a service technician enables designers to take the view of those responsible for the maintenance and repair of the designed model. This allows us to identify and remove obstacles.

4.2 Technology Switch

The addition of VR to the process cannot be understood as a classic form of an interruption. In this context, VR usage is considered in a differentiated way by the interviewees. On the one hand, it is described as a positive impact, when support is needed in the process, so it provides additional information that is required. On the other hand, it would be perceived as process interruption, if there is a constant change between both technologies (i.e., computer and VR) with a short time lag. To avoid constant pulling in and out of the VR headset, sufficient design of the VR to evaluate the design must be ensured. It must be possible to transfer the design in its entirety to VR, where **flexible CAD design evaluation** can then be performed **in VR** and changes noted.

"It would probably be a great support to look at, okay, the hanging is two meters, or the hanging is only one meter because otherwise it would simply disturb or be too bulky [for the design]. But I don't believe that it would only work like this, VR-glasses on, VR-glasses off, VR-glasses on [...] that would be rather annoying, but I don't think this is how it works." Interview 12

"Maybe a little more distracted for a moment, but that's because you're really in a different environment. But I find it much more complementary than that it interrupts the workflow." Interview 6

In this case, a hybrid interruption is perceived as a distraction due to the change in technology. However, it is not perceived as a distraction in the workflow. It is also interesting that the change to VR is described as a spatial change. First, this addresses the aspect of immersion, which is used in the context of the VR experience as an important indicator of VR usage and describes the degree of situational involvement. Second, it is perceived as a delay, which is central to the interruption process.

"Well, that's a media break for sure, because before that you sit there with the keyboard and the mouse and then you sit there with the glasses and you're really in the tunnel, but that's not negative. It's more positive that you get a new perspective and have a haptic experience. But I don't find this alternating in the sense that it distracts me from my work." Interview 13

"I wouldn't be bothered by it, but it's an addition for me." Interview 3

Some interviewees mentioned a factor that was particularly crucial for them. They explained that it was important for them to complete their thought or work process in the CAD program up to a certain point. They indicated that **autonomous time management** concerning VR integration was particularly critical to their positive perceptions of a work disruption due to technological change. Therefore, a special relevance for acceptance and implementation is to be assumed. With predefined time slots, they would not be able to integrate VR use into their work process according to their own needs and would tend to perceive the technology change as disruptive.

"If my thought process has been completed and I need a more visual representation or I need the feeling of being able to touch it […] then that would be a much smaller interruption for me than if someone said you now have a 15-minute time slot, now or never. And that would be a very strong factor for me in how I would perceive it." Interview 17

"For me, given time periods (for the VR use) would mean that I cannot finish my thought process in the CAD program. And while I'm using the VR, I'm still mentally sitting at my PC and continuing to draw, and then I don't know if that brings the same positive effect as if it just coincides with what I need because at that moment a change would be practically forced on me." Interview 10

To enable fast and efficient VR use to extend design work in CAD, it is important that it can be installed as a **permanently installed set-up**. This would reduce the interruption of work to a minimum effort since no time is needed to install and set up the VR. A fixed setup allows for quick and efficient use, which in turn would have a positive impact on the perception of work interruption.

"You'd have to integrate it so that you even have the option of leaving the VR in a room somewhere by default so that the setup time is shorter and you don't have to set it up." Interview 7

So, there are **benefit expectations for using VR**. The legitimate question of an appropriate alternative to viewing the design in VR rises. It is not possible to specify an alternative to view the design in a VR environment that is less disruptive to the workflow while providing such a realistic and cost-effective evaluation of the construction. It was mentioned that alternative options offer far less rich viewing, are of greater expense, and would significantly disrupt the work process.

"The question is, what else would I do? […] If I go into the production hall and look at a crane, then the greater interruption for me would be to go into another hall and see a crane that doesn't correspond to what I would ideally need but brings me this visualization effect in 3D in seemingly real size, then VR is an option that actually allows me a lesser interruption. Because what else is my alternative? To imagine it or to draw it on paper and all these are options that in my eyes are actually worse than the possibility of VR." Interview 17

Among the expected benefits of using VR is greater diversity in the work process. By extending the range of tasks, the traditional design process is transformed into a modern work process through digital transformation. Thus, the otherwise constant CAD on the computer can offer an alternative workflow in an innovative way supporting the actual process.

4.3 User-related Factors

Whether the use of VR during the design process is seen as rather disruptive or beneficial depends on different user-related factors. The personal attitude and the **readiness for innovation** regarding

enriching work processes with innovative technologies represent a decisive factor. If the employee has the motivation to integrate VR into the design process, the integration is seen as positively reinforcing.

"You have to be open-minded towards the technology of course." Interview 2

"I think it is also a personal characteristic that plays into it." Interview 8

Attitudes of employees and their **technical affinity** with the use of new technologies are alluded to, with the aspect of familiarity being important. Accordingly, employees who have a stronger **VR experience** or have developed a routine in dealing with VR are more likely to describe the use of VR positively than those who fall back on their established work pattern and perceive a technology switch as an interruption of their work process.

"I think it would be a support, but I think it's a personality issue. I think you can't simply put STAFF NAME there, for him it would probably be more of an interruption, or it would probably slow him down if he is not used to it. For someone young, who grew up with the modern media, for him this should not be a problem." Interview 15

"That definitely depends on the person and their technical affinity." Interview 1

For employees who are unfamiliar with VR technology and whose motivation to engage with it is low, the perception of a potential technology switch is associated with a negative attitude. They transfer the lack of familiarity with the VR technology to their attitude about supporting their work with it and are biased towards the technology switch during their work process

4.4 Conclusion

Based on the interviews, we were able to identify conditions that positively influence the perception of hybrid interruption due to technology switches. This means that when the conditions are considered, the interruption of CAD work by VR technology would potentially be perceived as less disruptive. We divided each of the three identified conditions (enabled expanded understanding, technology switch, and user-related factors) into subcategories for which we defined the expected impact on the design process (see Table 2).

Conditions	Subcategories	Expected impact
Enabled expanded understand-ing	Understanding of environmental conditions	Adaption of the design to real environmental requirements
	Understanding of scale	Accuracy of fit of parts
	Understanding potential issues regarding the maintenance	Change of perspective about the design
Technology switch	Flexible design in VR	Avoidance of constant mounting and dismounting of the VR Headset
	Autonomous time management	Optimal workflow structuring
	Permanently installed VR set-up	Increases ease of use
	Benefit expectations for VR use	Increases use of VR
User-related factors	Readiness for innovation	Change of design through innovative technology
	Technical affinity / VR Experience	Ease of use, efficient use

Table 2. Overview of the influencing factors.

5 Discussion

New technologies are a part of the innovation of traditional work processes. Particularly, VR technology provides different potentials to improve design processes by enlarging them. For the industrial sector, CAD modelling is the norm for designing machines. However, designers are not responsible for and show limited awareness of maintenance processes. Simulating the machine model in a virtual

environment enables the designer to empathize with the perspective of maintenance employees (Weigel et al., 2020). Nevertheless, the design process is interrupted by the additional use of VR due to a technology switch. Consequently, the question arises whether the use of VR in the CAD work process is the type of innovation that is conducive to process optimization. In addition, it is crucial to investigate which potential influencing conditions contribute to a positive understanding of the hybrid interruption through VR. To answer our RQ (*How can VR approaches be seamlessly integrated into traditional processes such as CAD work to support and enhance these processes?*) we refer to the process of crane design and surveyed designers and design-related employees to examine our approach.

This paper pursues the approach of the enlargement of working processes caused by new technology. By extending the CAD process with VR, the traditional process is interrupted in its actual execution flow, whereby designers have to change the technology. The assumption of an interruption is generally associated with a negative event that affects the performance of individuals (Tan and Richardson, 2011). Conversely, for the design process, this would imply that designers are impaired in their work process by extending their range of tasks with VR. However, there is literature that considers interruption as part of the work and not as a disturbing factor (Wajcman and Rose, 2011). By addressing hybrid interruptions, a type of interruption has been identified that shows a duality of effects on performance. Even if the primary task (i.e., CAD modelling) is interrupted by the secondary task (i.e., VR usage), the primary task is supported with feedback from the secondary task, thus improving performance (Addas and Pinsonneault, 2015). Since VR reflects an additional task of the design process, we consider VR usage as an extension of the CAD process. By extending the scope of a designer's job, the traditional process is interrupted but strengthened by the feedback providing valuable information about CAD models. The definition of conditions and subcategories, consistent with previous research, expands the understanding of hybrid interruptions.

Based on the interruption process we were able to adapt the design process. Similar to Wajcman and Rose (2011), we consider hybrid interruptions as part of the work process. New technologies offer the chance for new perspectives and although they interrupt the work process in its actual execution, they generate benefits that are supportive for the entire process. It should be noted that the process we present reflects a simplified representation of the design process and serves to clarify our approach, by reflecting only a part of the overall process. This paper explicitly uses the CAD process to examine the involvement of VR providing a positive view of hybrid interruptions in the work context.

For the implementation of innovative technologies in conventionally executed processes and the associated temporary interruption of the task flow, influencing conditions emerge that cause an expected impact on the process. In the course of our research, initial approaches were identified, which allowed us to derive influencing conditions to show the potential perception of VR use as a hybrid interruption within the CAD process. For this purpose, 3 influencing conditions (enabled expanded understanding, technology switch, and user-related factors) were identified (c.f. Table 2). Based on these, expected impacts could be implied to illustrate the impact of VR usage for the purpose of CAD work. For example, the technology switch (influencing condition) involves the permanent and fixed installation of the VR setup, which has an expected impact on the ease of use of VR. The simplicity of use is associated with the fact that VR use can happen without increased installation and setup efforts, thus reducing the interruption time. Among other things, this illustrates the use of VR in established work processes requires a concept and clearly modelled process (e.g., Castilla et al., 2013; Coburn et al., 2017). Based on existing research, we were able to abstractly represent the integration process using the interruption process and show to what extent the use of innovative technologies as VR, affects established processes. In terms of a hybrid interruption (Addas and Pinsonneault, 2015) of VR within the CAD process, we were able to clarify the duality of hybrid interruptions to the work process and show the influencing conditions as a basis for strategic measures for the VR use in work processes.

5.1 Implications for Theory

Regarding our RQ we consider interruptions with a new approach and derive implications for theory. While interruptions are often associated with negative implications and are mostly concerned with performance impairment, IS literature provides differentiation between a negative, positive, as well as

a hybrid form of interruption (Addas and Pinsonneault, 2015). Technology-induced interruptions (Tams et al., 2018) are ubiquitous and disturb work processes. However, if technologies are used and integrated effectively, they can enrich processes. This paper addresses this approach and examines interruptions from a different perspective: an interruption as a subtask (secondary task), caused by the extension of a task (primary task) and thus provides a value for the task process by feedback support.

For theory, investigations of interruptions should be increasingly oriented in the direction of positively influencing interruptions, particularly for tasks that can benefit from additional information. Generally, interruptions are considered a negative constraint on the performance of current tasks (e.g., Tan and Richardson (2021)). However, approaches such as Addas and Pinsonneault (2015) or Wajcman and Rose (2011) contradict a purely negative impact. Our research builds on these approaches and shows that hybrid interruptions (VR use) within an activity (CAD modelling) can positively support current as well as downstream processes (provided feedback). Hence, the definition of (hybrid) interruptions should be reconsidered regarding its duality of negative as well as positive impacts on performance.

Using the interruption process in a new way is applicable. Its structure can be related to work processes that provide the involvement of different tasks, whereby the primary task is interrupted by a secondary one through the change of tasks. Particularly the digital transformation of processes through innovative improvements, such as VR, provides these types of process structures. Therefore, it is conceivable that the process can also be transferred to other processes, in which a change of tasks is required.

5.2 Implications for Practice

Based on our findings, we can derive implications for practice. First, we find that a hybrid interruption can have positive effects for the interrupted worker, depending on whether the interruption enlarges the primary task. With this knowledge, work processes (in our case CAD processes) can be intentionally interrupted by VR use to provide an advantage if the VR usage adds value. This value can have very different expressions, but we refer to an evaluating value for design improvement.

Process modelers can build evaluative hybrid interruptions into previously linear processes. Especially for designers, VR offers an enormous potential, which was presented in this study. Here, the timing and frequency of the hybrid interruptions are important. Employees should be able to decide for themselves at what step they want to interrupt their work with a VR evaluation. Improvement of the product quality in terms of maintenance could also be achieved by an interruption through VR evaluation. The hybrid interruption through VR gives the designer a feeling for the subsequent steps, which can be incorporated into the design process. In this way, maintenance-unfriendly components and installation procedures can be identified in advance and corrective measures can be taken.

6 Limitations and Outlook

This study provides interesting qualitative findings around hybrid interruptions, but it has its limitations. The findings are based on a total of 17 interviews with employees from a German organization. Like any other empirical study, this study shows typical limitations of qualitative research (e.g., weak internal validation). The interviews provide first insights for considering hybrid interruptions as work improvement.

The following limitations can motivate further research. This study aimed to develop an approach that can be easily applied by practitioners so that more complex relationships were avoided. However, researchers can draw further conclusions and investigate other, more general questions that were not addressed within our study. For our approach, we used a qualitative method to understand hybrid interruptions by using VR. It became clear that it is difficult to identify which phenomena caused other phenomena. For instance, the perceived benefits of a hybrid interruption can be influenced by personal preferences. In such cases, it may be helpful to investigate interdependence through quantitative analysis. Quantitative studies are also able to address a broader population and provide generalizable findings. Furthermore, it can be assumed that personal factors as character or interests play a significant role in the hybrid interruption through VR. However, the focus of this study was solely on the relationship between the design process and the hybrid interruption through VR. Considering other

factors could broaden the perspective on interruptions in general and for work processes, where performance is particularly endangered. Therefore, this study offers potential for further investigation and can contribute to a more general theory of appropriate interruptions. This would open the possibility of including additional factors (e.g., personal attitudes) in the analysis, whereby a quantitative approach would serve as theory verification.

Despite the unanswered questions, this study has strengths that should be considered. VR interruptions in the CAD process were identified as a positive rather than a negative impact on work performance. These results are of interest to both practitioners and researchers as they provide both a basis for the strategic integration of VR technologies into traditional work processes and a new perspective on existing research and consequently expand it. Although the design of the interruption (i.e., VR use) was not the main part of this research, our findings can be used for the further development of research focusing on the development of an IT artifact. Methodologies from the field of design sciences are promising for designing and evaluating VR.

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