Multimodal Technologies and Interaction

MDPI

Article

Wellbeing at Work—Emotional Impact on Workers Using a Worker Guidance System Designed for Positive User Experience

Magdalena Laib [1,*], Christina Haspel [1], Christopher Stockinger [2], Lucas Polanski-Schräder [2], Philipp Dücker [2], Kristian Voll [2], Patrizia Schiffrer [1] and Michael Burmester [1]

[1] Information Experience Design Research Group (IXD), Hochschule der Medien, University of Applied Sciences, Nobelstraße 10, 70569 Stuttgart, Germany
[2] Institute for Ergonomics and Human Factors (IAD), Technical University of Darmstadt, Otto-Berndt-Str. 2, 64287 Darmstadt, Germany
* Correspondence: laib@hdm-stuttgart.de

Abstract: Wellbeing at work can be achieved through different strategies; designing for a positive user experience (UX) is one way. However, the relationship between wellbeing and professionally used technology is rather unexplored, especially in work areas that are far from desktop work such as worker guidance systems (WGSs) used in assembly processes. In this paper, we first described a qualitative evaluation (using the valence method) of a prototype WGS designed for a positive UX. The evaluation showed that it elicited far more positive than negative feelings. Based on the results, we improved and redesigned the prototype. We then implemented it in a realistic setting and quantitatively compared it with an established WGS. It was shown that the prototype elicited more positive feelings than the established system, whereas there were no differences in the number of negative markers. Thus, one can assume that the improvement of UX in the redesigned system was due to the positive UX design concepts. However, there were no significant differences in the mood questionnaires. The paper showed that positive experiences at work can be achieved when the design of professional technology is focused on a positive UX. Long-term studies should further investigate whether these experiences lead to a generally elevated mood.

Keywords: user experience; human needs; worker guidance system; experience categories

Citation: Laib, M.; Haspel, C.; Stockinger, C.; Polanski-Schräder, L.; Dücker, P.; Voll, K.; Schiffrer, P.; Burmester, M. Wellbeing at Work—Emotional Impact on Workers Using a Worker Guidance System Designed for Positive User Experience. *Multimodal Technol. Interact.* **2022**, *6*, 87. https://doi.org/10.3390/mti6100087

Academic Editor: Mark Billinghurst

Received: 27 July 2022
Accepted: 28 September 2022
Published: 12 October 2022

1. Introduction

Happiness, wellbeing, and positive emotions are valued and expected in many situations and contexts. There are contexts in which it seems easier to experience positive emotions. For example, this is the case when we start off for vacations. We expect experiences of relaxation or adventure depending on what kind of vacation we have planned. When we open our social networking app, we expect experiences of socializing or successful self-marketing depending on the intention we have when using this app. Furthermore, if everything works out as planned, we actually experience these kinds of feelings in those contexts.

Other contexts are not associated with positive emotions at first glance. One such context is work. Work is mostly related to task fulfillment, stress, seriousness, accuracy, effort, etc. Perhaps this is the reason why professionally used systems and products are less researched in experience design. We find that rather surprising as our work showed us that there are plenty of possibilities to experience positive emotions at work [1–3]. Zeiner and colleagues [4] collected almost 350 positive experiences at work, analyzed and clustered them, and formulated 17 experience categories that describe possibilities for positive experiences at work. For example, at work, we often act in teams and we often use technology. As Diefenbach and Hassenzahl [5] found out, relatedness is one central psychological need when interacting with technology. Thus, we can use technology to design for experiences of relatedness. When designing for experiences of relatedness when using a customer relationship management system, we found out that providing technological possibilities to thank colleagues or visualize virtual teams by using profile pictures enhances positive experiences [6]. In another project, we designed software for sales personnel [1]. We conducted experience interviews [7] and learned that sales personnel enjoy working together with their customers on their projects. The resulting design concept called "project collage" supports the cooperation between the customer and salesperson and brings the salesperson more into the role of a moderator and the customer into the role of an expert.

However, still, there are areas of work where we find little attempts to design for positive experiences. One such area is industrial manufacturing [8]. In these workplaces, worker guidance systems are in use, and this paper will give insights into how to design for positive experiences in worker guidance systems (WGSs).

In the theoretical part of this paper, we will mention why it is essential to enhance wellbeing at work. Then, we will give information about the nature of worker guidance systems. After that, we introduce the concept of a positive user experience (UX) and how it is related to wellbeing at work. We will present design concepts for WGS that were created with a focus on positive user experience in a pre-study [9]. The focus of this work was to report how those design concepts were evaluated and improved. Therefore, we presented a qualitative study evaluating the UX of a prototype of a WGS, followed by a quantitative study comparing the improved prototype with the original system. In the end, we will discuss the results.

1.1. Wellbeing at Work

Increasing wellbeing at work is not just of personal interest of employees. When researching the role of positive emotions, Barbara Fredrickson [10,11] showed that positive emotions broaden people's thought-action repertoires and that, among other positive effects, they enhance psychological resilience. It was also shown that it reduces stress when employees have positive experiences [12]. Thus, providing employees with more possibilities for positive experiences is also of interest to employers. There are many options increasing positive experiences at work, for example, through organizational psychological interventions such as job rotation to increase the variety of benefits that come with the job such as good food or team events.

Another way is to increase positive experiences within the occupation itself. As we often work using technology, it makes sense to design professionally used technology with a focus on positive experiences, which is called a positive user experience (UX).

1.2. User Experience

According to Marc Hassenzahl, UX "is a momentary, primarily evaluative feeling (good–bad) while interacting with a product or service" [13] (p. 12). According to him, a positive feeling is evoked when psychological needs are fulfilled. There are several models of psychological needs such as the self-determination theory with 3 fundamental needs [14], the 10 need candidates of Sheldon et al. [15], or the 16 needs profile of Reiss and Haverkamp [16]. A recent integrated model with 13 fundamental needs and 52 sub-needs based on six typologies of fundamental needs has recently been published by Desmet and Fokkinga [17]. To design systems that fulfill psychological needs, methods have been developed to introduce psychological needs into ideation processes, e.g., by need cards [5,17,18]. However, there are also alternative approaches such as focusing on positive emotions [19] or empirical approaches such as analysis of positive practices [20] or context-based categories of positive experiences [4,21].

WGSs are designed to guide people through particular work processes. It is essential that they help people reach their goals effectively, efficiently, and satisfactorily, which signifies a good usability [22]. However, since they take up much space in the work routine, they should be designed not only for a good usability but also for a positive user experience.

1.3. Worker Guidance Systems

WGSs are a digital approach to supporting employees with assembly-based information. They can be described as cognitive assistance systems that are integrated into the work environment and support employees with relevant assembly-related information that is context-aware and without additional effort for the employees [23–27].

The term "assistance" describes the predominant purpose of these systems as a relief in varying degrees, not the entire substitution of employees [28]. Assistance systems, in general, can be categorized following human information processing, such as perception, decision, and execution assistance systems [29]. The first two categories are often summarized as cognitive assistance [24]. Following this approach, worker guidance systems can be allocated to decision assistance systems since the difficulty for workers in highly variable assembly is to make appropriate, product variant-related decisions. The key purpose of worker guidance systems is to provide employees with appropriate, product-, and variant-specific information, often by showing work instructions step by step (e.g., [30]). The term "guidance" refers to guiding employees through the assembly process by showing relevant information [31]. Other terms, e.g., "worker information system" [32] or "worker assistance system" [33], are common as well and describe more or less identical systems. Furthermore and more generally, "electronic performance support systems" [34] and "information support system" [35] are terms to describe these systems.

To systematize the design of these systems, Reinhart [24] distinguishes three design fields for WGSs: information level, information design, and information device to structure the design of WGSs. The information level summarizes the type (e.g., parts lists, process descriptions at workstations, sequences, and processes of the entire production) and level of detail of the information contained in the system. The information design describes how this is designed, for example, which medium is used or which type of interaction with the users is aimed for. The third design field, information device, focuses on the hardware implementation of the system and thus primarily on the information device used to display information (e.g., stationary display, tablet, and head-mounted display).

WGSs, thus, form the central interface in production for employees. All three design fields, thus, also influence the interaction of the employees and how they evaluate it. These subjective attitudes can be made more tangible through the user experience approach.

1.4. Research Questions

In a pre-study, we created a positive UX version of an existing WGS [9]. With the help of an experience potential analysis (EPA) [36], we designed concepts with a positive UX and implemented them into a prototype to enrich the existing WGS. An EPA is based on experience categories [4,21,37]. Experience categories describe positive experiences in a particular context, for example, at work or in the kitchen. With an EPA, one can systematically analyze a product or service for its potential to increase positive experiences of its users. In the pre-study, we conducted an EPA based on the experience categories of Zeiner et al. [4] that describe positive experiences at work (see Table 1). The prerequisite of an EPA is to learn more about the product or service under investigation. Therefore, we conducted a context-of-use analysis. According to the method manual [38], we used a shortened version of the context-of-use analysis of Thomas and Bevan [39]. With the EPA, we analyzed the WGS for experience potentials. In the concept phase, we used an adapted version of the brainwriting-pool method [40], where a group of people engages in a creative process to design positive UX design concepts.

Table 1. Experience Categories in work contexts according to Zeiner et al. [4].

Cluster	Experience Category
Resonance	Receiving feedback Giving feedback Appreciation
Social support	Receiving help Helping others Teaching others
Challenge	Being given a challenge Rising to a challenge
Engagement	Solving a problem Experiencing creativity
Organization	Keeping track of things Finishing a task
Communication and new experiences	Connecting with others Exchanging ideas Creating something together Experiencing something new Contributing to something greater

In study 1, we wanted to find out if those positive UX concepts elicit positive experiences in the target group and, therefore, conducted a qualitative evaluation using the valence method [41,42]. We hypothesized that participants would feel more positive than negative emotions while interacting with the prototype of the WGS. Based on the results of this study, we improved the prototype WGS. In study 2, we conducted a Wizard-of-Oz study [43] in a realistic setting and quantitatively compared the prototype with an established WGS to find out which version of the WGS (redesigned prototype vs. established) is more positively experienced. Therefore, the prototype was animated to provide a realistic impression of a functional WGS. Our hypothesis was that the participants would experience more positive emotions when interacting with the redesigned prototype than with the established system. We also hypothesized that there would be differences in mood between the two systems after the assembly process.

2. Study 1—Qualitative Validation and Resulting Improvements

2.1. Theoretical Background

In this first study, we qualitatively evaluated the UX of a prototype of a WGS. Therefore, we applied the valence method [41], a formative evaluation method that provides information about positive and negative experiences with a product or service. Those experiences are analyzed referring to their eliciting aspects. With the results of the valence method, designers can understand which design features contribute to positive experiences and why.

2.2. Method

2.2.1. Participants

The participants were recruited via the public relations channels of the Mittelstand 4.0-Competence Centers Usability and Darmstadt (websites, Twitter, and LinkedIn). The requirements for participation were a minimum age of 18 years and experience in industrial assembly.

In total, ten people participated in the study. Eight of the participants identified as men and two as women. Participants were between 19 and 58 years old (M = 35.90, SD = 14.07). Three of the participants stated that their highest level of education is high school graduation. Three participants indicated that they had finished vocational training, and four participants reported that they had obtained university degrees.

Three participants reported having no work experience. One participant indicated one year of work experience, and another one reported nine years of work experience. Two participants had ten years of work experience, and two others had twelve years. One participant indicated 25 years of work experience. One participant stated that they had no previous experience with WGSs and had never heard of them before. Four participants reported that they had already heard of WGSs but had not yet personally worked with them. Three participants stated that they had used such systems a few times, and two participants reported that they had frequently worked with worker guidance systems themselves.

The study was conducted as part of a collaboration between the Mittelstand 4.0-Competence Centers Usability and Darmstadt. Both competence centers are part of the initiative Mittelstand Digital, funded by the German Federal Ministry for Economic Affairs and Climate Action.

For participating, subjects received EUR 50 along with a voucher for the online store of the Technical University of Darmstadt. Participants were not informed about the research questions prior to the study.

2.2.2. Prototype

As stated above, we conducted a contextual inquiry [44] as a prerequisite of the EPA [9,36] and an EPA itself in a pre-study [9]. On that basis, we designed several design concepts focusing on positive UX for a WGS in a pre-study. Based on the existing user interface of a worker guidance system, a prototype including the new positive UX design concepts was set up. Therefore, the original user interface was complemented with the following design concepts, whose appearance resembled the original user interface (see Table 2).

Table 2. Positive user experience (UX) design concepts for worker guidance system (WGS).

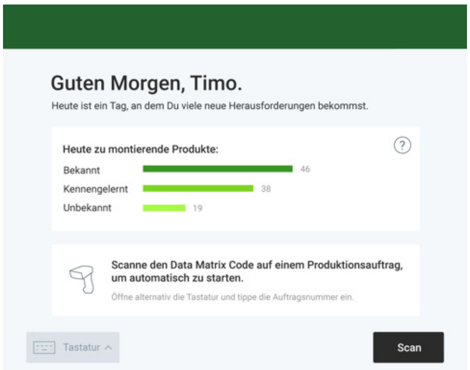
Name		Description and Screenshots of the Positive UX Design Concept
Daily preview	Description	The positive UX design concept "daily preview" refers to the whole construction process and is based on the experience category "being given a challenge" [14]. When the worker logs into the worker guidance system, he or she sees a bar chart that provides an overview of the tasks of the day arranged according to their familiarity (bekannt/familiar = constructed more than 50 times, kennengelernt/got to known = 10 to 50 times, unbekannt/unknown = constructed less than 10 times). The idea behind this positive UX design concept is to provide a forecast for the day and to motivate the user to learn new things (due to the unknown tasks that expect them).
	Screenshot	

Table 2. *Cont.*

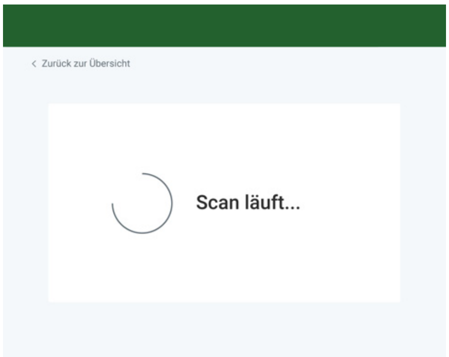
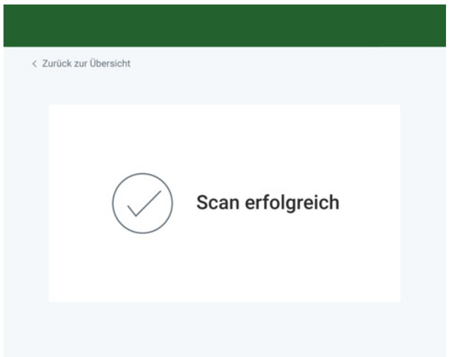
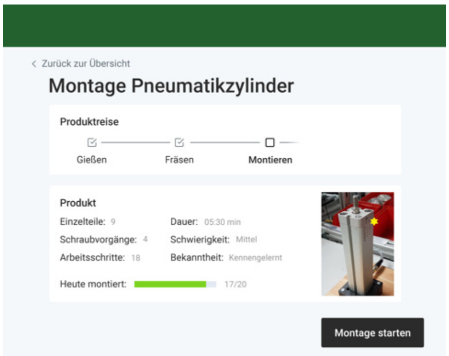
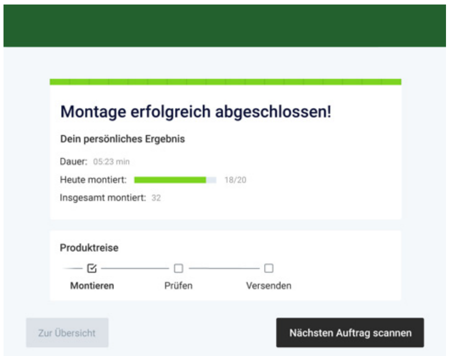
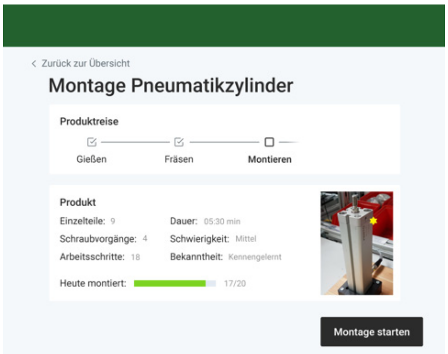
Name		**Description and Screenshots of the Positive UX Design Concept**
Enter order slip	Description	The positive UX design concept "enter order slip" is based on the experience categories "receiving feedback" and "keeping track of things". When the worker scans the order slip, he or she receives feedback from the system that the scan was successful.
	Screenshots	 
Product journey	Description	The positive UX design concept "product journey" (see the upper part of the first screenshot) refers to the construction process in association with the whole organization and is based on the experience category "creating something together". It provides the worker with information about the journey of the assembly part. After the order slip was scanned, the screen displayed in the screenshot appears. The product journey shows where the product is coming from (in this case, "gießen/casting" and "fräsen/milling"). At the end of the construction process, the screen in the second screenshot is shown. The lower part of the screen delivers information about the further use of the assembly part (in this case, "prüfen/verifying" and "versenden/shipping"). The "product journey" tells the workers that they work together with others on the same product and that its finalization is a joint performance.
	Screenshots	 
Product overview	Description	The positive UX design concept "product overview" (see the lower part of the screenshot) is based on the experience category "keeping track of things". It provides information about the product, e.g., how long it takes to construct it and how many pieces it consists of. The intention of this positive UX design concept is to provide the workers with information about the product to make them feel competent.
	Screenshot	

Table 2. *Cont.*

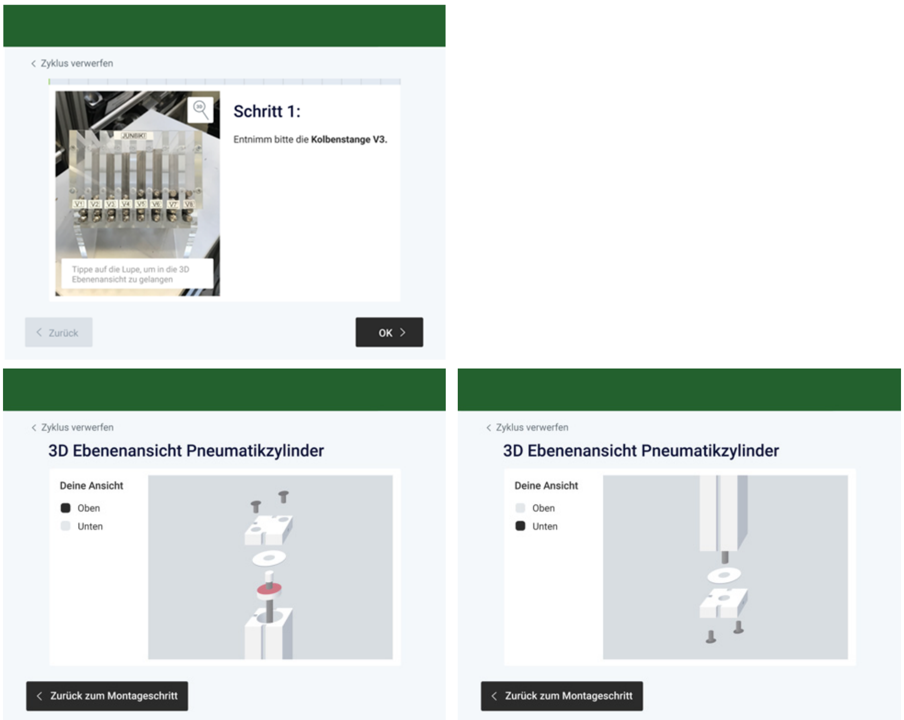
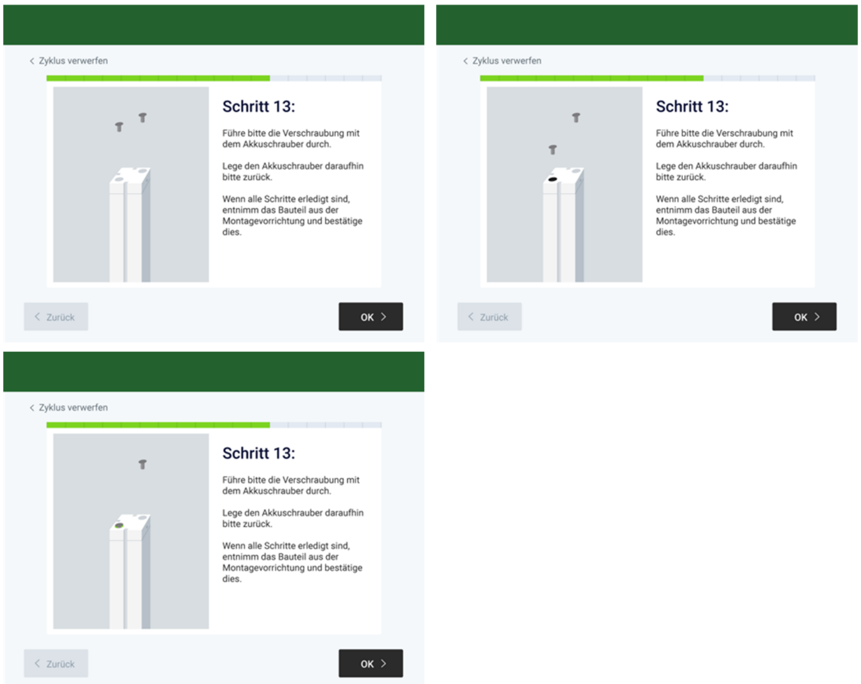
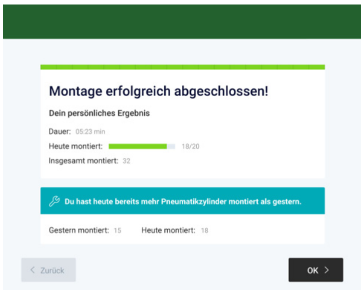
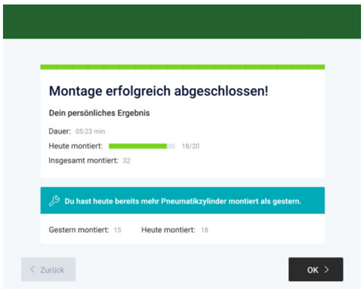
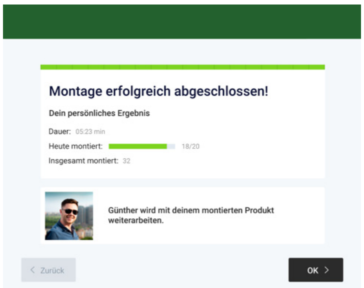
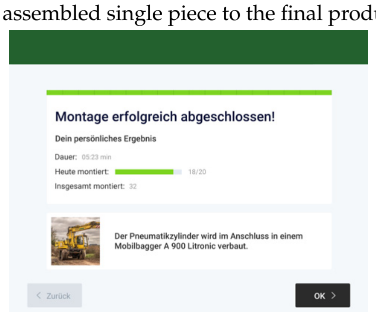
Name		Description and Screenshots of the Positive UX Design Concept
Three-dimensional model	Description	The positive UX design concept "three-dimensional model" is based on the experience category "keeping track of things". Via a magnifier icon, the worker has the possibility to jump to a different screen where a three-dimensional layer view of the product is provided. The workers should have the possibility to receive more background information about the product if they want to fully understand the product and its construction process.
	Screenshots	
Screw animation	Description	The positive UX design concept "screw animation" is based on the experience category "finishing a task". The screwing task is visualized by screws entering their respective slot accompanied by a sound. This positive UX design concept intends to support the feeling of having acoustically accomplished a task.
	Screenshots	

Table 2. *Cont.*

<table>
<tr><th>Name</th><th></th><th>Description and Screenshots of the Positive UX Design Concept</th></tr>
<tr><td rowspan="2">Personal results</td><td>Description</td><td>The positive UX design concept “personal results” (see the upper part of the screenshot) is based on the experience categories “receiving feedback” and “keeping track of things”. It tells the worker his or her personal results concerning the construction process just conducted, e.g., the duration of the process. The intention of this concept is to provide workers with information about their performance so that they can monitor their progress and celebrate their best performances, for example.</td></tr>
<tr><td>Screenshot</td><td>
</td></tr>
<tr><td rowspan="2">Performance statement</td><td>Description</td><td>The positive UX design concept “performance statement” (see the lower part of the screenshot) is based on the experience category “receiving feedback”. It gives the worker feedback based on comparisons within his or her individual performance with a focus only on successful comparisons. If there are no positive comparisons, this screen will not be displayed. The statement says: “Today, you have already assembled more pneumatic cylinders than yesterday”.</td></tr>
<tr><td>Screenshot</td><td>
</td></tr>
<tr><td rowspan="2">Passing on to a colleague</td><td>Description</td><td>The positive UX design concept “passing on to a colleague” (see the lower part of the screenshot) is based on the experience category “creating something together”. It tells the worker which colleague is going to use the assembly part next (it is Günther in the screenshot). It should support a team feeling.</td></tr>
<tr><td>Screenshot</td><td>
</td></tr>
<tr><td rowspan="2">Forecast to thefinal product</td><td>Description</td><td>The positive UX design concept “forecast to the final product” (see the lower part of the screenshot) is based on the experience category “creating something together”. It displays a picture of the final product in which the assembly part will be installed (the assembled pneumatic cylinder is installed in a mobile excavator). The intention of this UX design concept is to widen the perspective from the small assembled single piece to the final product.</td></tr>
<tr><td>Screenshot</td><td>
</td></tr>
</table>

The positive UX design concepts appeared in the above order among other already existing screens. Those were very similar to the original, except that we made language changes. At large, we maintained the original texts. In order to let them sound more accessible and more polite, we implemented "please" where possible and added some punctuation. As the final screen, "Performance statement", "Passing on to a colleague", or "Forecast to the final product" was either shown. Those were randomized across the participants. Therefore, they could not receive as many markers as the other positive UX design concepts.

2.2.3. Valence Method

To conduct the evaluation, we used the valence method [41], which is a method for formative evaluation to improve the UX of an existing product or prototype based on the UX model of Hassenzahl [13,45]. Data acquisition happens in two phases: (1) exploration and (2) retrospective interview.

(1) Exploration: In the original process, the participants are invited to experience the product without a scenario or a task for 6–8 min. While exploring, they have to monitor their emotions: every time they feel good, they have to push a plus button (set a positive marker), and every time they feel bad, they are requested to push a minus button (set a negative marker). The exploration phase is recorded.

(2) Retrospective interview: In this phase, a participant and an interviewer watch the video of the exploration phase together. Every time the participant had pushed a plus or minus button, the video is stopped. The interviewer then asks what had elicited the respective emotion (design element and design aspect). With the help of the laddering technique [46], the interviewer then tries to figure out the personal meaning of that certain design element and optimally the underlying psychological need.

Due to the research question and pandemic situation, the test setting had to be adapted: at that time, the regulations at universities and laboratories were very strict so as to not meet in person. Therefore, a virtual setup of the experimental setting was created (see Figure 1). The screens were imported into a Figma document to create a clickable prototype of the application. Figma (https://www.figma.com/, accessed on 19 November 2020) is an online collaborative prototyping tool that allows its users to design and share their work [47]. This prototype could then be shared via a link with the participants, who were able to independently navigate the application. Furthermore, a virtual remote control with a plus and minus button was included in the Figma document, so that participants could directly set positive and negative markers in the exploration phase as their emotions emerged. By pressing the minus button, a virtual red indicator light illuminates, and by pressing the plus button, a virtual green indicator light illuminates next to the corresponding button. The set markers were thus clearly visible on the video.

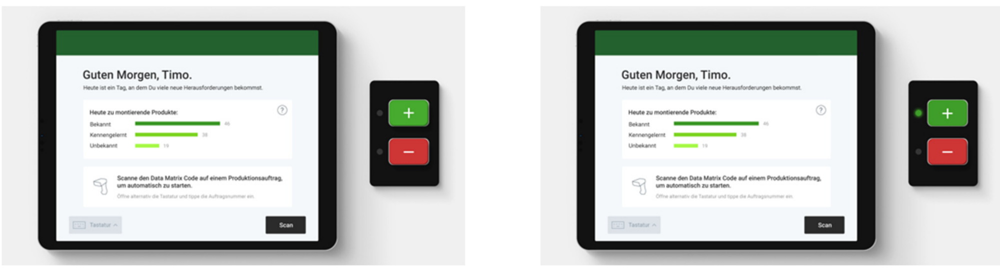


Figure 1. Virtual setup of the experimental setting. Virtual tablet in the center shows Table 2. To the right of virtual tablet, there is a virtual remote control for setting positive (green plus button) and negative (red minus button) valence markers. Right keyboard shows how a virtual indicator light (here: green) illuminates in response to pressing the (green plus) button.

The valence method is a qualitative method. Therefore, it can be assumed that—compared with quantitative methods for data collection—a smaller sample size is sufficient to collect reliable data. Burmester recommends that the product to be investigated should be examined with the valence method by 10–15 participants [41].

2.2.4. Procedure

For each participant, screens were personalized, meaning that the name and email address that appeared on the screens were adjusted to the participant's name.

Each interview started with a welcome and technology check. After that, the study's purpose was explained. Consent to recording was inquired (in advance in written form and verbally during the online session).

After the recording had begun, the interview started with questions about the professional background of the participants: description of their job, how long they work there, if they use a WGS and, if yes, which one; they were optionally asked for tasks for which they use the WGS.

Participants then filled in the sociodemographic questionnaire: age, sex, educational level, applicable study subject, current job title, previous experience with assembly work, and previous experience with WGSs.

Afterward, the interviewer explained the study structure, and the participants practiced the principle of the study by setting markers while exploring a digital brochure. Subsequently, the participants opened the Figma prototype and shared their screens. The interviewer began to read the scenario. The scenario was visualized with scribbles on screens. In a nutshell, it told participants to imagine that they work in an assembly where they produce pneumatic cylinders and that they are on their way to their morning shift. They meet their colleagues and go change before they arrive at their workstation, where they scan their order and start with the assembly process led by a WGS. The scenario ended when the participants had to imagine that they returned to their workplace after a coffee break. Now, they began to click from page to page of the prototype and set their markers. For the concept screw animation, the interviewer had to play a sound from their mobile phone (Wizard-of-Oz style). When the participants had seen all the screens, the recording was stopped and exported. After a short break, the second phase began. The interviewer shared the recording of the exploration phase, and, in a retrospective interview, all markers were laddered. At the end of the interview, the participants described their impression of the worker guidance system and named the three aspects that elicited very positive (and negative) emotions. This second phase was also recorded.

2.2.5. Analysis

All interviews were transcribed. For every marker, the following was documented:

- Participant's code
- Time stamp
- Valence
- Element
- Design aspect
- Transcript of the text passage
- Meaning
- Experience category
- Psychological need

The transcript of the interview was used to derive the meaning of the statement and underlying experience category, as well as the underlying psychological need. For this, we referred to the experience categories of Zeiner et al. [4] and the need model of Desmet and Fokkinga [17]. In this analysis, we mainly focused on the meaning of the statement. Afterward, markers were assigned to the respective design elements. The number of positive and negative markers that were set for each design element was counted. Additionally, every marker was analyzed referring to its individual meaning. On the basis of this analysis, we derived suggestions for improving the UX of the prototype.

2.3. Results

Overall, 239 markers were set, 185 positive and 54 negative. Figure 2 shows how many positive and negative valence markers were set for each positive UX design concept.

The results of the qualitative analysis for all positive UX design concepts are presented in Table 3.

Table 3. Results of valence method for all positive user experience (UX) design concepts.

Name of the Positive UX Design Concept	(+) [1]	(−) [2]	Qualitative Analysis
Daily preview	11	4	Participants liked that the concept shows that the workers still can learn something new and develop. It shows what to expect and facilitates planning. It suggests that one's own work contributes to a progress. On the contrary, it shows how much work lies ahead, prevents surprises, and makes too many specifications. It supports the feeling of being a machine.
Enter order slip	3	1	Positive comments referred to the provided security of the feedback. It was negatively commented that scanning again leads to loss of time.
Product journey	7	1	It was positively connotated that one can feel safe because there are other persons checking on the product that has just been assembled. One receives information about the further use of the product, and the need for control is addressed because it is traceable, which is the current step in the assembly process and when one's work is completed. It was negatively commented that this screen and the previous one are too similar.
Product overview	10	3	According to the participants, this concept supports the feeling of being in control because it shows what to expect, and it also motivates due to the fact that one has already carried out part of the work. The negative comments referred only to the graphic visualization: due to bad photographing, one loses focus on the essential. Furthermore, the star seems misplaced and has an unfavorable symbolism.
Three-dimensional model	12	0	Participants appreciated the possibility to further qualify. According to them, it supports understanding the product so that they feel more in control and safe. It strengthens the identification with one's own occupation. The view is reduced to the essential, and such a clear presentation supports efficient working.
Screw animation	19	5	It was positively connotated that this animation distinguishes from the other screens, which mostly include pictures and text. The animation, thus, loosens up the assembly process and leads to new motivation. It provides an exact visualization of the process, and the sounds assure about the correct performance of the task. As the order of the screwing can be individually determined, workers can autonomously act. Negative comments referred to the sound, which was perceived as inadequate. The screwing process was perceived as too detailed in order to be equipped with a sound for each screwing. It was also commented that the whole screen was perceived as unnecessary.
Personal results	14	0	Participants liked the feedback to one's own performance and progress. They liked that it shows what one has already achieved and that you can learn something about your own working performance. It contributes to motivation, and the green part of the progress bar was perceived as a positive color.
Performance statement	1	0	The performance statement led to joy about the praise.
Passing on to a colleague	1	0	When passing on to a colleague, it supported the feeling of being part of a whole.
Forecast to the final product	3	0	Participants liked that they could contribute to something greater.

Note: [1] number of positive valence markers; [2] number of negative valence markers.

When we had a closer look at all markers, it became apparent that there were also elements besides the positive UX design concepts that received a high number of markers (see Figure 3).

Figure 3 shows that there is a decrease in the number of markers between step 3 (six markers) and scan (four markers). Thus, we decided to have a closer look at all other elements that received six or more markers; the results can be seen in Appendix A (see Table A1).

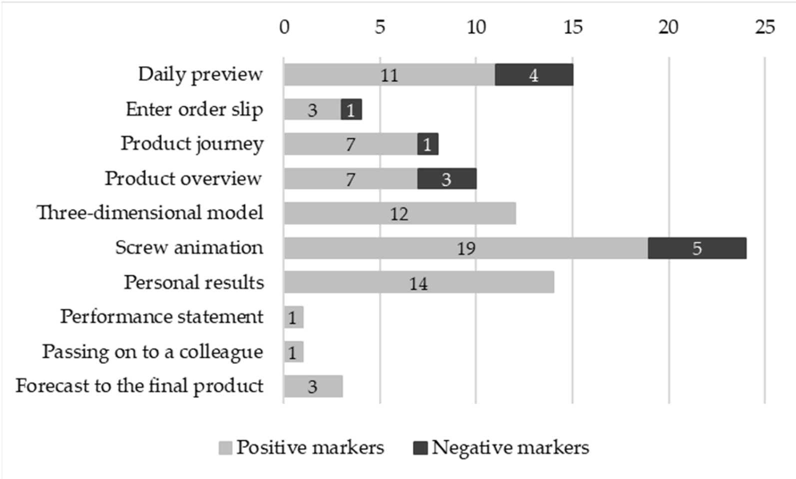


Figure 2. Amount of valence markers for positive UX design concepts.

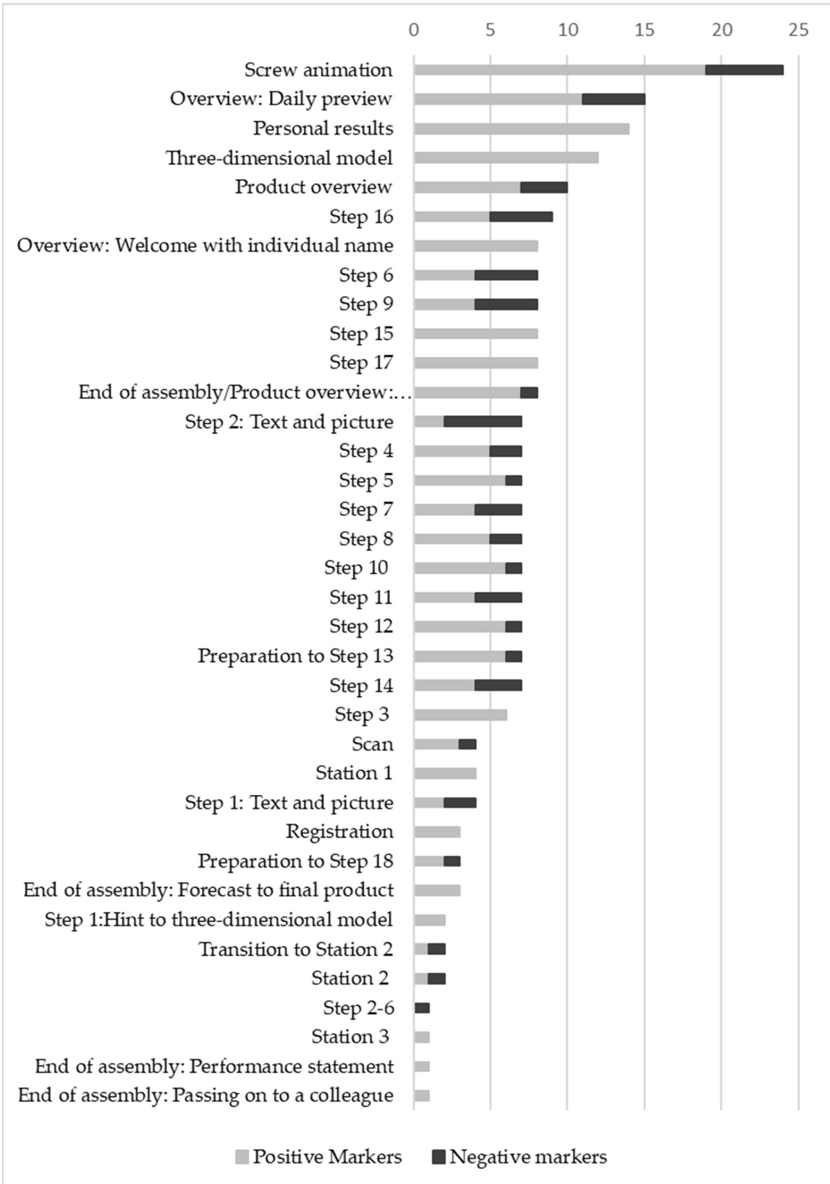


Figure 3. All set valence markers (positive and negative) assigned to respective design elements.

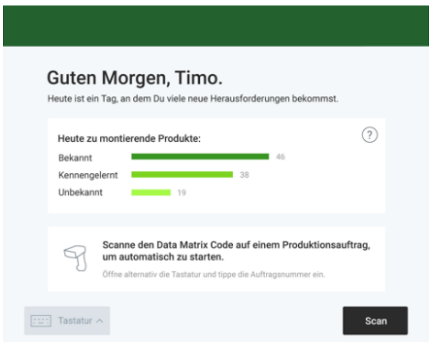
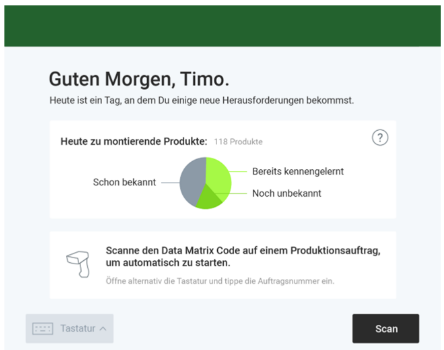
2.4. Discussion

In the presented study, we investigated the UX of a design prototype of a WGS. The prototype was based on an existing WGS and enriched with positive UX design concepts that we had developed in a pre-study [9]. For the evaluation, we used the valence method [41], which told us which design elements were positively or negatively perceived. Therefore, we counted the positive and negative valence markers. We conducted interviews with our subjects using the laddering technique. On the basis of those qualitative data, we will derive actions to improve the UX of the positive UX design concepts.

As there is not much research concerning positive UX in WGSs, we wanted to know if we could elicit positive experiences in those systems applying an EPA. The results show that this was the case: in total, the positive UX design concepts received far more positive than negative markers, thus eliciting more positive than negative feelings. Nevertheless, the interview data show that there are options for improvement. We now discuss the results in detail and suggest necessary adaptions to further improve their UX in the order the concepts appear in the assembly process.

The positive UX design concept *Daily preview* received eleven positive and four negative markers. For its redesign, we mainly considered the negative comments of the participants: people criticized that the graphic shows how much work lies ahead, prevents surprises, and makes too many specifications. According to them, it supports the feeling of being a machine. Our redesign goal then was to prevent users from stress and overload. Thus, we did not focus on exact amounts and numbers and deleted the numbers of each category. We just kept the total amount but presented it in a very light color. In addition, we changed the bar diagram into a pie chart to focus more on the distribution of the different categories than on exact amounts (see Table 4).

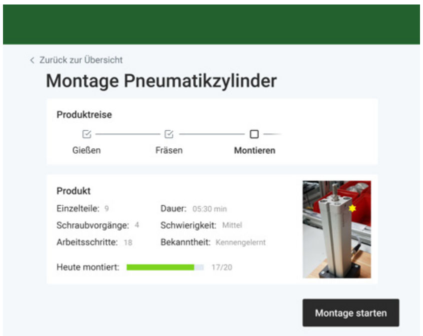
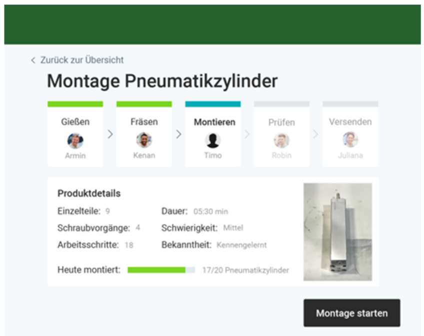
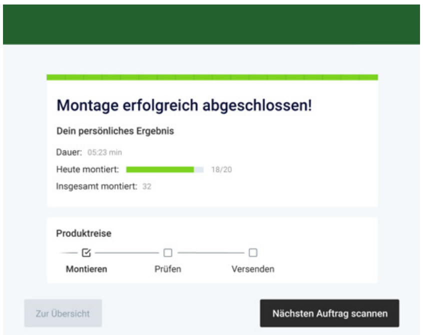
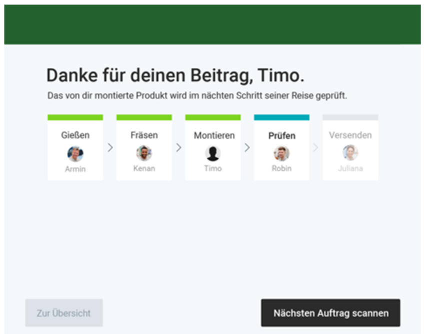
Table 4. Original positive UX design concept and respective redesign of "Daily preview".

Illustration of the Original Positive UX Design Concept	**Illustration of the Redesign of the Positive UX Design Concept**
	

We did not make any changes to the positive UX design concept *Enter order slip* because the negative comment referred to the scanning itself and not to its depiction.

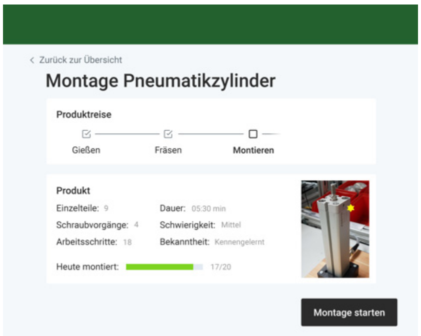
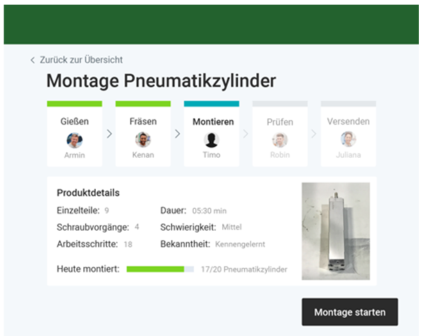
The positive UX design concept *Product journey* received seven positive markers and one negative marker. The evaluation showed that there was little connection to the addressed experience category "creating something together". Although the concept was predominantly experienced to be positive, the explanations of the participants did not meet the characteristic of "creating something together". Therefore, the aim of the redesign was to improve its fit to the experience category for which it was initially designed. To emphasize the aspect of teamwork in the assembly process, the concept has been extended, so it shows not only what steps the product has already gone through (in this case, "gießen/casting" and "fräsen/milling") but also what steps will follow after assembly (in this case, "prüfen/verifying" and "versenden/shipping)". In addition, the name and photo of the coworker performing the task were added to each step of the product journey to make it more personal and to create a sense of community. In addition, the current step in the assembly process was highlighted by marking the previous steps with a green bar and graying out the upcoming steps. For the current step (in this case, “montieren/assemble”), a placeholder for the name and photo of the employee who is currently working with the WGS was also inserted. Another modification is that the preview of the next steps after the completion of the current step of assembly is no longer shown together with the positive UX design concept *Personal results*. Instead, the preview of the two subsequent steps (in this case, “prüfen/verifying” and “versenden/shipping”) is shown on a separate screen, which completes the whole construction (see Table 5).

Table 5. Original positive UX design concept and respective redesign of “Product journey”.

<table>
<tr><th>Illustration of the Original Positive UX Design Concept</th><th>Illustration of the Redesign of the Positive UX Design Concept</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

The positive UX design concept *Product overview* received ten positive and three negative markers. The graphic visualization was modified in response to the negative feedback where participants reported that due to bad photographing, one loses focus on the essential. Furthermore, the star seems misplaced and has an unfavorable symbolism. Thus, the photo was replaced with another showing the assembled product lying on a neutral background and without a star. To clearly indicate what the green progress bar on the bottom refers to, the name of the corresponding product (in this case, “17/20 Pneumatikzylinder/17/20 pneumatic cylinders”) was added after the number, although this was not noted by the participants (see Table 6).

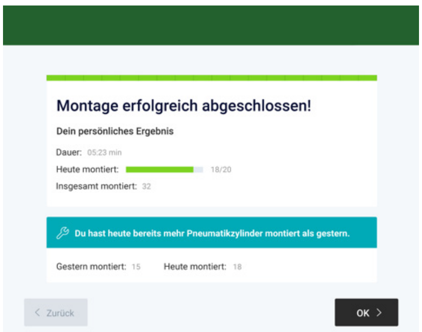
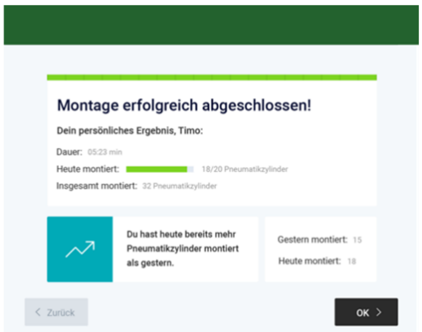
Table 6. Original positive UX design concept and respective redesign of "Product overview".

Illustration of the Original Positive UX Design Concept	Illustration of the Redesign of the Positive UX Design Concept
	

The positive UX design concept *Screw animation* received nineteen positive and five negative markers. When revising it, the negative feedback of the sound was addressed. The playful confirmation tone was replaced by the playing of a male voice that counts the number of bolted screws. In this case, the voice counts from one to two. The counting voice is also intended to reinforce the character of the underlying experience category "finishing a task" of the positive UX design concept.

The positive UX design concept *Personal results* was positively marked 14 times and obtained no negative markers. It was revised by further emphasizing the elements that led to positive feedback: a placeholder for the name of the employee currently working with the WGS was added to the headline announcing the personal results to make the address more personal (in this case, "Dein persönliches Ergebnis, Timo/Your personal result, Timo"). To provide a clear understanding of what the personal results refer to, the name of the product has been added after the number of the products assembled on that day (in this case, "18/20 Pneumatikzylinder/18/20 pneumatic cylinders") and the total number of this product ever assembled (in this case, "32 Pneumatikzylinder/32 pneumatic cylinders") (see Table 7).

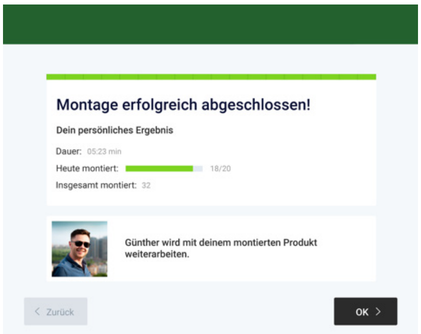
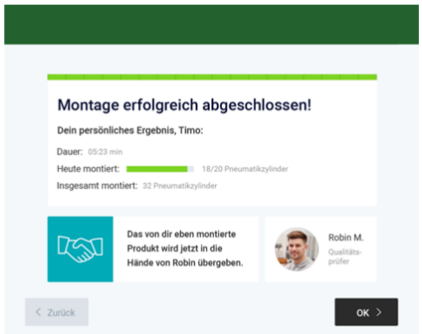
Table 7. Original positive UX design concept and respective redesign of "Personal results" and "Performance statement".

Illustration of the Original Positive UX Design Concept	Illustration of the Redesign of the Positive UX Design Concept
	

The positive UX design concept *Performance statement* received one positive marker. It was redesigned to make it more prominent and to enhance the impact of the positively experienced elements. To achieve this, first, the wrench icon was replaced by an icon of an ascending arrow to generate an immediate association with an improvement. Second, the numbers of products assembled at different times, which are used to make a statement about improvement, were directly placed on the right of the statement that more pneumatic cylinders were assembled today than yesterday. In addition, the font size of the performance statement was increased, and the statement was centrally placed on a neutral background (Table 7).

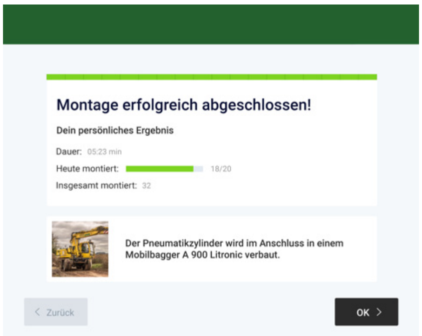
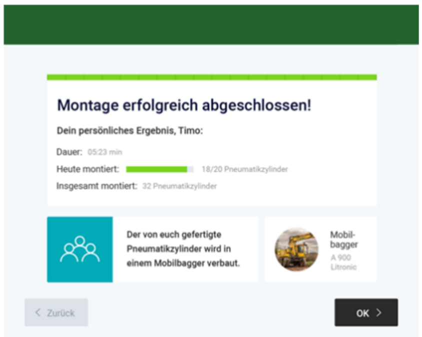
The positive UX design concept *Passing on to a colleague* received one positive marker. The aim of redesigning was to enhance the effect of a positive experience. First, the announcement that a colleague will now continue working with the product just assembled was centrally placed and its font size was enlarged. Second, to the left of the announcement, an icon showing a handshake on a blue background was added to create an immediate association with the underlying experience category "creating something together". Third, the photo showing the colleague to whom the product is passed after its assembly was replaced by another one depicting a male person in an industrial hall wearing workwear, which fits the context better than the previous photo. The new photo also shows the same person who continues to work with the assembled product in the positive UX-concept product journey. In addition, the name of the colleague was adjusted (from "Günther" to "Robin M.") because the previously used name rather fits an older man, while the new photo shows a young man (see Table 8).

Table 8. Original positive UX design concept and respective redesign of "Passing on to a colleague".

Illustration of the Original Positive UX Design Concept	Illustration of the Redesign of the Positive UX Design Concept
	

The positive UX design concept *Forecast to the final product* received three positive markers. It was redesigned to further emphasize the elements that led to positive experiences and to extend the concept with elements that target the underlying experience category "creating something together". The aspect of teamwork was highlighted in the information on how the assembled part is installed in the final product by assigning the assembled part to the employee and his or her colleagues (in this case, "Der von euch gefertigte Pneumatikzylinder wird in einem Mobilbagger verbaut/The pneumatic cylinder you manufactured is installed in a mobile excavator." Note: The German word "euch" is the dative of "you", which refers to a group of people). On the right of the information about the future use of the assembled part, an icon was added, showing a group of three people on a blue background (see Table 9).

Table 9. Original positive UX design concept and respective redesign of "Forecast to the final product".

<table>
<tr><th>Illustration of the Original Positive UX Design Concept</th><th>Illustration of the Redesign of the Positive UX Design Concept</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

The prototype with the redesigned positive UX design concepts was then used in the next study, where we compared the original WGS with the positive UX prototype in a realistic assembly situation.

3. Study 2—Quantitative Validation

3.1. Theoretical Background

There are a few studies that quantitatively measured the effects of a positive UX with a bigger sample. Kohler et al. [48], for example, validated their interaction pattern with 14 participants. Divided into two groups (with and without pattern), the participants had to perform a task, and their performance was validated using objective data such as the number of breaks. Additionally, they implemented questionnaires measuring the subjective impression of UX. When evaluating WGSs, they are mainly compared with static, paper-based assembly instructions, or different hardware approaches are compared mostly with regard to assembly performance and often in highly abstracted experimental setups (e.g., [49–58]).

The actual design of the systems, such as the user interface or the information design, has hardly been considered in empirical research. Watson et al. [59] and Jeske et al. [60] explored the content design of information in WGSs and showed that it influences assembly performance, especially in training situations. Stockinger et al. [30] also showed that especially the information level and information design affect the assembly performance. The importance of a good user experience of WGSs is regularly emphasized. It is important to emphasize that the mentioned works did not pursue the systematic UX design of WGSs.

With this study, we wanted to fill these two gaps: we wanted to evaluate the UX of the redesigned prototype with a larger sample and carry out this evaluation in a realistic setting with a realistic system to compare. Therefore, we compared the redesigned prototype with an existing WGS. In a realistic setting, 30 participants (15 in each group) had to assemble a pneumatic cylinder using one version of a WGS (either the existing system or resigned prototype in a Wizard-of-Oz version). We then compared the two systems regarding the amount of elicited positive experiences, participants' estimation of UX, participants' mood and feeling of happiness, and the estimated duration of the assembly.

Therefore, the exciting question of this study is whether the systematic UX-related design of the WGS makes a difference regarding UX. In contrast to the mentioned studies that especially focused on assembly performance, this study highlighted the subjective evaluation of users as the most important result of UX design.

3.2. Method

3.2.1. Participants

In total, N = 30 people participated in the study. Twenty-two of the participants identified as men and eight as women. Participants were between 18 and 32 years old (M = 24.2, SD = 3.07). Twenty-eight participants reported having no assembly experience. Two participants indicated one year of assembly experience. All participants stated that they had no previous experience with WGSs and had never heard of them before. All participants were registered in a technical field of studies (18 of them in engineering studies), so it can be assumed that they had a high affinity for technology. The participants were recruited via personal acquisition and public notice at the Technical University of Darmstadt.

The study was also conducted as part of a collaboration between the Mittelstand 4.0-Competence Center Usability and Mittelstand-Digital Center Darmstadt, which is the follow-up project of the Mittelstand 4.0-Competence Center Darmstadt. Both centers are part of the initiative Mittelstand Digital, funded by the German Federal Ministry for Economic Affairs and Climate Action.

For participating, the subjects received a present worth EUR 10. The participants were not informed about the research questions prior to the study.

3.2.2. Prototype

In the second study, the redesigned version of the prototype of the first study was used and compared with a similar visual and tablet-based WGS. The system only slightly differs from the original system that was used as a template when designing the positive UX design concepts in the pre-study [9]. The latter was not used for comparison in the study because it is based on static monitors and other hardware components that would have influenced the comparability with the optimized, tablet-based system. The content of the assembly instructions (images and texts) is identical in the systems, so that assembly could be performed equally well with both systems (Figure 4).

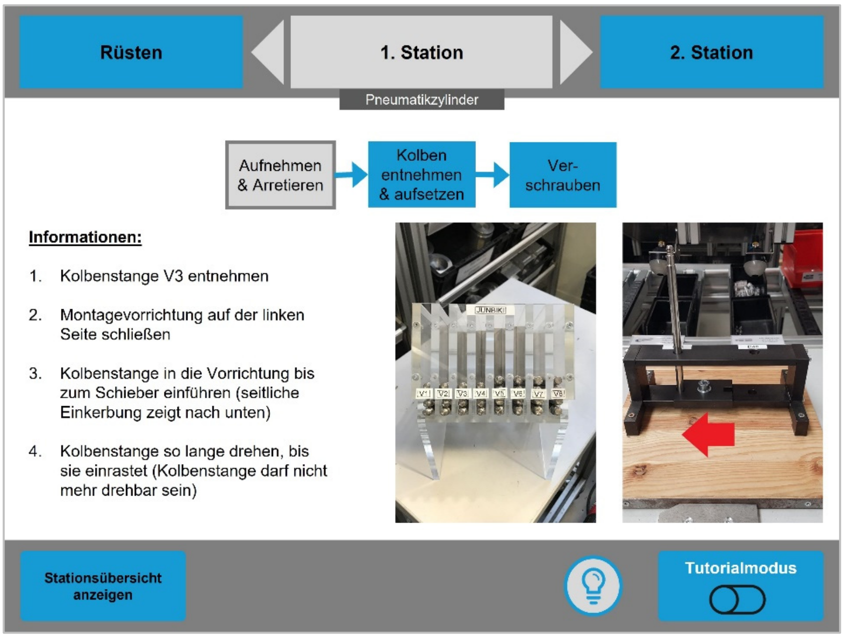


Figure 4. Comparison system that was used by the control group in the study.

3.2.3. Valence Method

As in the first study, the valence method was used to evaluate the UX. In the first study, we set the focus on a content-oriented evaluation. The focus of the second study was on a quantitative analysis. Therefore, we used an adapted version of the valence method, which was already successfully implemented in the evaluation of positive UX design concepts in the form of prototypes [6]: the participants set markers, but there is no follow-up interview to analyze the markers. The idea is to find out which version elicits more positive (and negative) markers. Contrary to the original procedure, no valence markers were collected during the interaction with the prototype in the exploration phase. The only task the participants had in this phase was to use the WGS to assemble the product. In the retrospective interview, the interface of the WGS was watched together with the participant. Screen by screen, the participants were asked to set their markers when recognizing positive or negative emotions. In order to quantitatively evaluate the results, we compared the amount of positive and negative markers between the two variants of the WGS.

3.2.4. Questionnaires

In the second study, various questionnaires and scales were used.

First, the German version of the Positive and Negative Affect Schedule (PANAS) [61,62] was employed to assess the participants' current affect. It consists of 20 items and measures the dimensions of the negative affect (e.g., "nervös"/"nervous") and positive affect (e.g., "freudig erregt"/"excited") with 10 adjectives each, using a five-point scale (1 = gar nicht/very slightly or not at all, 5 = äußerst/extremely). Watson et al. evaluated the PANAS scales and found it to be internally consistent (Cronbach's α= 0.84–0.90) [61].

Second, the meCUE 2.0 questionnaire [63] was used to assess the user experience. Since meCUE 2.0 is a modular questionnaire, only modules III (user emotions), IV (consequences of usage), and V (global attractiveness) were used in the study as they are helpful in answering the research question. Module III consists of twelve statements (e.g., "Das Produkt nervt mich."/"The product annoys me.") to measure positive and negative emotions. Module IV consists of six statements (e.g., "Wenn ich könnte, würde ich das Produkt täglich nutzen."/"I If I could, I would use the product daily."), which are rated using seven-point Likert scales (1 = lehne völlig ab/strongly disagree, 7 = stimme völlig zu/strongly agree). It measures the intention to use and product loyalty. Module V is a single item ("Wie erleben Sie das Produkt insgesamt?"/"How do you experience the product as a whole?") that captures an overall judgment of the product on a bipolar scale (-5 = als schlecht/as bad, 5 = als gut/as good). Minge et al. separately evaluated all modules and found Cronbach's α= 0.83–0.94.

Third, to assess the current feeling of happiness, a visual analog scale with the endpoints "überhaupt nicht glücklich"/"not happy at all" and "außerordentlich glücklich"/"extraordinarily happy" was used (0–100).

Fourth, the participants were asked to estimate the perceived duration of the assembly process in minutes and seconds.

The sociodemographic questionnaire asked about sex, age, assembly experience (1 = none, 4 = very high), field of study, and whether participants had ever worked with a WGS before (yes/no).

3.2.5. Procedure

The second study was conducted at the Process-learning Factory CiP (Industrial Productivity Center) of the Technical University of Darmstadt. The participants were welcomed to the factory and taken to the workstations that were used for the study. In the beginning, the participants were asked to sign the consent form. They were then requested to complete a sociodemographic questionnaire. Afterward, they were given an explanation of the course of the following study. The participants were informed that their task was to assemble a pneumatic cylinder several times with support from a WGS, which is part of the workstations. They were also told that they would have to fill out various questionnaires and that they would be interviewed afterward. In the end, the participants had the opportunity to clarify questions.

After the instruction, the participants were asked to assemble the pneumatic cylinder five times, supported by one of the two versions of the WGS: one group of 15 participants used the redesigned version of the prototype. The second group was designed as a control group and used the original WGS that was used on the assembly line. Which of the two versions the participants were exposed to was assigned by investigators with the goal to parallelize both group compositions regarding sex, native language, and academic background. In both versions, the participants went through the same steps to assemble the pneumatic cylinder. To assemble the product, it was necessary to change the workstation twice in each case. After each confrontation with one of the two versions of the WGS interfaces, the participants were asked to indicate their global experience of the product as well as their current feeling of happiness. They were also asked to estimate the duration of the assembly process. Moreover, they had to fill in the PANAS and meCUE questionnaires. Afterward, they were interviewed regarding their experiences in the WGS-supported assembly.

In the end, the participants were briefed on the aims of the study, handed their incentives, and seen off.

Thus, all data generated during the study can be attributed to the two groups of subjects: the one group that used the redesigned prototype and the group that used the original WGS. The dependent variables are also accordingly divided between the groups. The statistical analysis accordingly focused on mean comparisons of the two groups, which were calculated with unpaired two-sample *t*-tests via IBM SPSS Statistics 27. A further descriptive analysis of the valence markers that were set in the WGS-supported assembly focused on the five design elements of the redesigned WGS prototype that received the most valence markers.

3.3. Results

3.3.1. Statistical Analysis

The results of all *t*-tests are shown in Table 10. First, we compared the amount of positive and negative markers between the two groups. The participants set more positive markers in the group that worked with the redesigned version of the prototype than the group that worked with the original WGS. There was no significant difference regarding the negative markers (see Figure 5, average frequency).

Table 10. Results of *t*-tests.

Variable	T	df	Sig.	d	Redesigned Prototype *M*	Redesigned Prototype *SD*	Original WGS *M*	Original WGS *SD*
Amount of positive markers	−6.05	20.46	<0.001 ***	2.324	7.60	2.95	2.47	1.46
Amount of negative markers	0.70	28	0.49	2.87	3.67	2.16	4.40	3.43
UX score	−3.38	28	0.002 **	0.41	0.35	0.32	−0.16	0.48
Positive affect score of the PANAS	−1.14	22.32	0.27	0.69	3.61	0.49	3.33	0.85
Negative affect score of the PANAS	−0.60	28	0.55	0.30	1.34	0.28	1.27	0.32
User emotions (meCUE, module III): Positive emotions	−0.17	28	0.87	0.55	3.21	0.54	3.18	0.55
User emotions (meCUE, module III): Negative emotions	1.36	28	0.18	0.76	3.13	0.58	3.51	0.90
Consequences of usage (meCUE, module IV): Intention to use	0.30	28	0.77	1.23	3.78	1.25	3.91	1.22
Consequences of usage (meCUE, module IV): Product loyalty	0.76	28	0.46	1.20	3.82	1.25	4.16	1.16
Global attractiveness (meCUE, module V)	−0.18	28	0.86	1.99	7.87	1.88	7.73	2.09
Current feeling of happiness	0.11	28	0.92	13.97	74.87	15.04	75.40	12.81
Estimated duration of the assembly process	−0.30	26 [1]	0.77	335.32	1249.00	318.48	1211.15	355.01

Note: *** $p < 0.001$, ** $p < 0.01$; [1] 2 participants were excluded from analysis as they estimated a duration of 2 min. It can be assumed that they did not correctly understand the instruction.

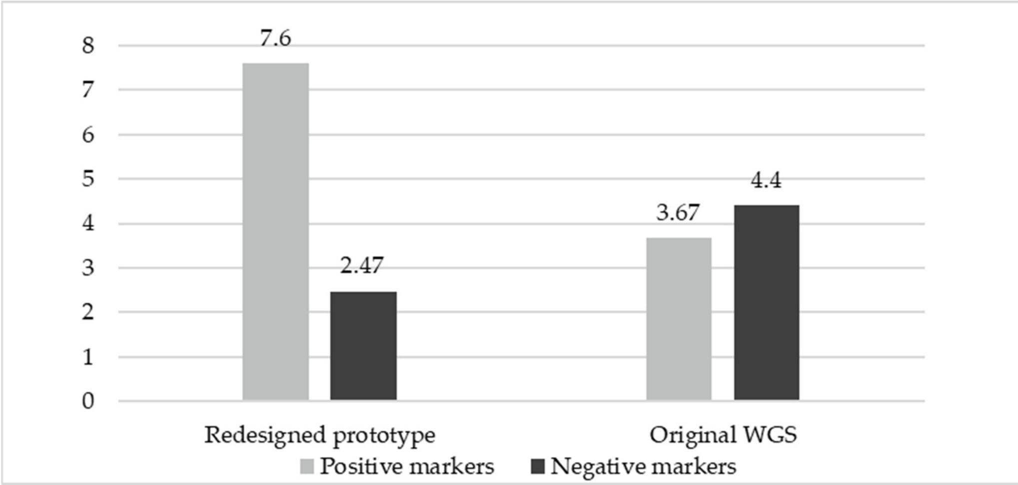


Figure 5. Comparison between both types of WGS regarding positive and negative markers (average frequency).

There was a significant difference in the UX score, which was significantly higher in the redesigned prototype. Burmester [41] categorized the UX score as follows: negative UX: −1 to −0.33; neutral UX: −0.33 to 0.33; and positive UX: 0.33 to 1. Thus, the UX of the original WGS is neutral (M = −0.16, SD = 0.48), and the UX of the redesigned prototype is positive (M = 0.35, SD = 0.32).

There were no significant differences in positive and negative affect (PANAS), user emotions (meCUE, module III: positive and negative emotions), consequences of usage (meCUE, module IV: intention to use and product loyalty), global attractiveness (meCUE, module V), current feeling of happiness, and estimated duration of the assembly process.

3.3.2. Descriptive Analysis

The results of further descriptive analysis of the valence markers indicated that the following design elements in the redesigned prototype received the most valence markers (top five): positive UX concepts "personal results", "forecast to the final product", "daily preview", "product overview", and the progress bar (placed at the top of each screen, supporting the assembly process and highlighting the positive UX concept "personal results"). Figure 6 illustrates the distribution of valence markers.

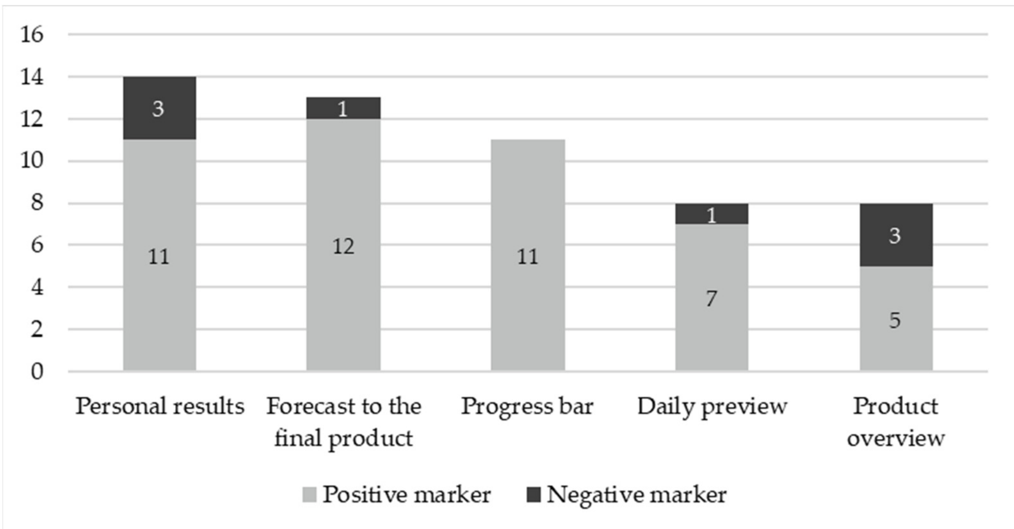


Figure 6. Absolute frequency of positive and negative valence markers of design elements in redesigned WGS prototype that received the most valence markers.

The UX scores of four of the five design elements indicated that they were positively experienced (personal results: UX score = 0.57; forecast to the final product: UX score = 0.85; progress bar: UX score = 1.00; daily preview: UX score = 0.75). The UX score of the design element "product overview" indicated that it was neutrally experienced (UX score = 0.25).

3.4. Discussion

In the second study, we compared the redesigned prototype with an existing WGS in a realistic setting. Two groups of participants used either the one or the other system to assemble a pneumatic cylinder. Subsequently, the participants filled in questionnaires measuring their mood, their assessment of user experience, their current feeling of happiness, and their estimation of the duration of the assembly process and indicated how many positive experiences they had when using the WGS.

The results showed that the participants had significantly more positive experiences when using the redesigned prototype. We can thus assume that the positive UX design concepts had an effect in the way that they elicited more positive feelings while using the WGS.

The UX score of the redesigned WGS was also significantly higher than that of the existing WGS. Moreover, there was no difference in the number of negative markers. Furthermore, the results of the descriptive analysis of the five elements of the redesigned prototype with the most frequent valence markers revealed that these are all elements that only exist in the redesigned prototype and not in the original WGS. In addition, all these elements were positive UX concepts (personal results, cf. Table 7; forecast to the final product, cf. Table 9; daily preview, cf. Table 4; product overview, cf. Table 6) or, in the case of the progress bar, part of it (e.g., cf. Table 7). Moreover, all of these elements received descriptively more positive than negative valence markers, and four of the elements (personal results, forecast to the final product, progress bar, and daily preview) were positively experienced according to the UX score. The UX score of the element "product overview" was neutral. Overall, therefore, it can be concluded that the improvement of UX in the redesigned system can be attributed to the positive UX design concepts.

On the one hand, we see differences in the positive emotions of the user between the two compared systems. On the other hand, all other comparisons regarding the effects on mood changes in the participants (PANAS, meCUE module 3, and current feeling of happiness) remained nonsignificant. The reason might be that the effects of the higher number of positive markers in the redesigned WGS are not of short-term nature. To find out if they have long-term effects, the redesigned prototype would have to be implemented for a longer time.

Module 4 of the meCUE measured intention to use and product loyalty; the differences were nonsignificant. This might be traced back to the fact that people use the WGS as an assistance to perform a certain task, in this case to assemble a cylinder. The situation in which the test took place (industrial environment, observation situation, assembly of complex components) certainly dampens the perception of design differences and focuses on resources for the correct execution of assembly tasks—just as under realistic conditions in practice. The informative contents of the compared systems, more precisely the work instructions, were identical in text and illustrations in both systems. This may indicate that these informative components as well as their ability to guide users through the assembly task were primarily assessed by the subjects.

There are certain limitations concerning the interpretability of the study results. With 15 people in each group, the power of the test was too low [64]. Thus, the study should be replicated with a greater sample. In addition, the systems were only used for the study's purpose. To further evaluate the impact of the redesign, the WGS should be implemented in real work environments over a longer period of time.

4. General Discussion

We started this paper with the finding that wellbeing at work is essential. It is essential for employees because they have a right to a good life, and a good life goes together with positive experiences. Wellbeing at work is also essential for employers because providing their employees with opportunities for positive experiences increases their resilience and reduces their stress. With this paper, we wanted to show that positive experiences at work can be elicited through the technology we work with. Therefore, we chose a field of work where designing technology for positive experiences is not common yet: worker guidance systems (WGSs) that are used in assembly.

For this, we used a screen-based WGS. This was chosen because the WGSs used in practice are also predominantly screen-based, and, thus, a high transferability could be achieved. In doing so, we limit the influence of the user's assessment of the technology itself to a minimum.

We started the first study with a prototype of a WGS that was complemented with positive UX design concepts that had been developed in a pre-study [9]. We assumed that the participants would set more positive than negative valence markers due to the implemented positive UX design concepts. We conducted a qualitative evaluation with the valence method and were able to demonstrate that more positive than negative feelings were elicited as we had hypothesized. Based on the findings, we revised the prototype. In the second study, we quantitatively compared the revised prototype with an existing WGS. One group used the revised prototype to assemble a pneumatic cylinder and one group the established WGS. We assumed that the UX of the redesigned system would be better than that of the established system and that the participants would feel better after assembling with the redesigned system than with the established WGS. As hypothesized, we could demonstrate that the participants reported more positive feelings when assembling with the revised prototype than with the original WGS. The UX score of the revised prototype was also positive and significantly better than that of the original WGS, which was experienced neutral according to the UX score. However, there were no differences in mood after assembling between the two WGSs.

Study 1 demonstrated that the participants had more positive than negative feelings when interacting with the prototype that was designed for positive experiences. Study 2 complemented those findings in showing that the participants reported more positive feelings when using a WGS that is designed for eliciting positive experiences than an established WGS. The approach to design for a positive UX elicits more positive feelings in users so far. Thus, this approach seems to contribute to a higher wellbeing in users also in a professional context.

However, those positive effects were not strong enough to have an impact on the improvement of the mood of the participants. One can assume that the effects are not strong enough to cause changes in such a short time such as after one assembly process. There are many interventions in positive psychology such as *Three good things* [65] that are requested to perform for a longer period of time. It can be concluded from this that the effects of a better UX only come apparent after a longer period of time. Therefore, a long-term study should be conducted.

We explicitly chose the working field of WGSs in assembly processes to conduct our studies as we found that it is an exemplary field of work that is neglected when it comes to designing for positive UX. The results support the assumption of a lack of positive experiences in existing systems, as there was a significant difference in the UX of both systems where the UX score of the established system was neutral and the UX score of the redesigned system was positive. Thus, we showed in this paper that it is possible to effectively improve the UX of those systems.

In this paper, we showed that explicitly designing for a positive UX is a promising way to contribute to an improved wellbeing at work, even in very industrial work contexts. Designing work tools is one facet of work design. If we design those tools with a focus on positive experiences, we contribute to the wellbeing at work.

Author Contributions: Conceptualization, M.L., C.H., C.S., L.P.-S. and M.B.; methodology, M.L., C.H., C.S., L.P.-S., P.D., K.V., P.S. and M.B.; software, C.S. and P.S.; validation and formal analysis, M.L., C.H., C.S., L.P.-S., P.D. and K.V.; investigation, C.H., P.D., K.V. and P.S.; resources and data curation, M.L., C.H., C.S., P.D. and K.V.; writing—original draft preparation, M.L., C.H. and C.S.; writing—review and editing, L.P.-S., P.S., and M.B.; visualization, M.L., C.H., C.S. and P.S.; supervision, M.L., C.H., C.S., and M.B.; project administration, M.L., C.H. and C.S.; funding acquisition, C.S. and M.B. All authors have read and agreed to the published version of the manuscript.

Funding: The study was conducted as part of a collaboration between the Mittelstand 4.0-Competence Centers Usability and Darmstadt. Both competence centers are part of the initiative Mittelstand Digital funded by the German Federal Ministry for Economic Affairs and Climate Action, funding numbers: 01MF17013A and 01MF21006A.

Institutional Review Board Statement: Ethical review and approval were waived for this study due to informed consent.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data supporting the reported results can be obtained.

Acknowledgments: Thank you to Elena Arnold for doing interviews.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Results of qualitative analysis of design elements in WGS prototype that received 6 or more markers and are not part of positive UX design concepts.

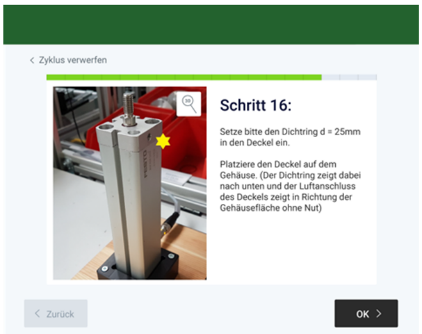
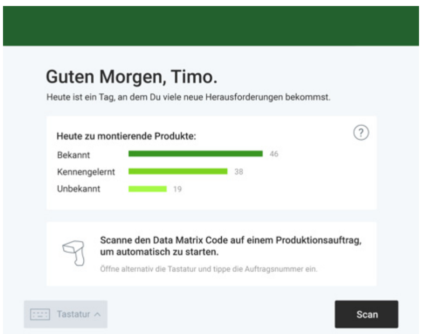
Name of the Design Element	Screenshot	(+) [1]	(−) [2]	Qualitative Analysis
Step 16		5	4	It was positively perceived that the star marks the exact spot but that it would be preferred if there was a circle around the relevant area instead of a star.
Welcome with individual name		8	0	Participants liked that the system welcomed them with their individual name. It was positively mentioned that they felt appreciated and motivated. They felt a more personal relation to their work and less pressured. They also liked that the salutation was adapted to the time of the day.

Table A1. *Cont.*

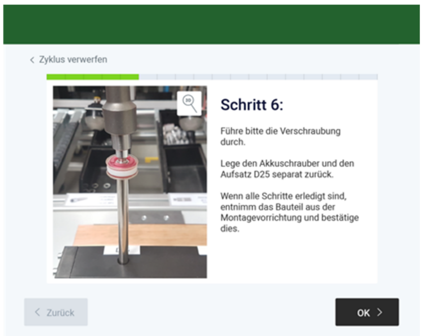
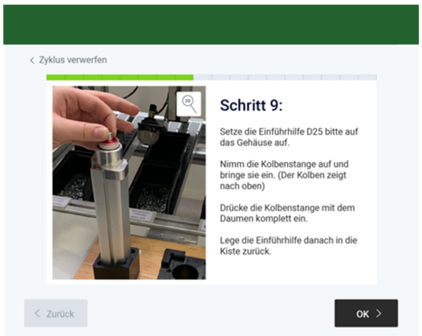
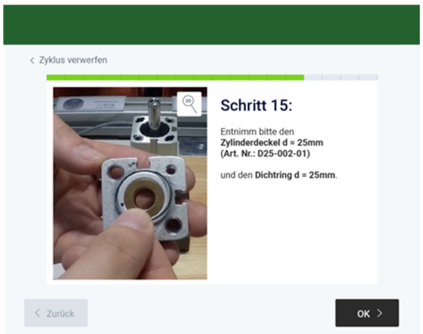
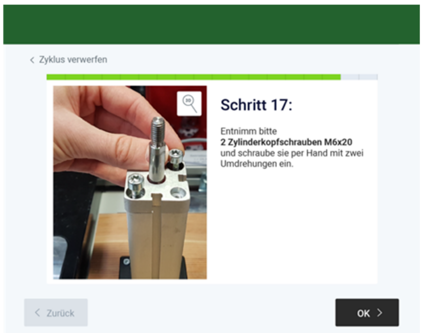
<table>
<tr><th>Name of the Design Element</th><th>Screenshot</th><th>(+) [1]</th><th>(−) [2]</th><th>Qualitative Analysis</th></tr>
<tr><td>Step 6</td><td>
</td><td>4</td><td>4</td><td>For some participants, the instructions were very clear; others needed more exact information (e.g., when the screwing is fine) and a more structured text.</td></tr>
<tr><td>Step 9</td><td>
</td><td>4</td><td>4</td><td>Some participants benefitted from the precise instructions; for others, there was too much text.</td></tr>
<tr><td>Step 15</td><td>
</td><td>8</td><td>0</td><td>Participants found the presentation clear, the construction part was focused, and the presented hands relate.</td></tr>
<tr><td>Step 17</td><td>
</td><td>8</td><td>0</td><td>Participants found the presentation clear, the construction part was focused, and the presented hands relate.</td></tr>
</table>

Table A1. *Cont.*

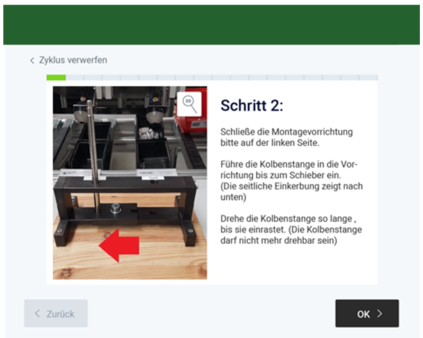
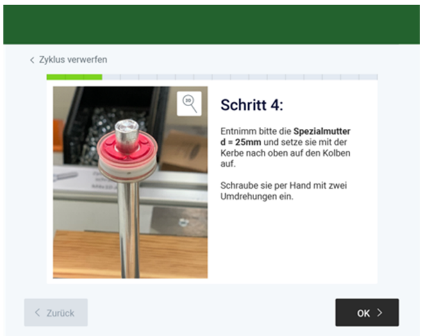
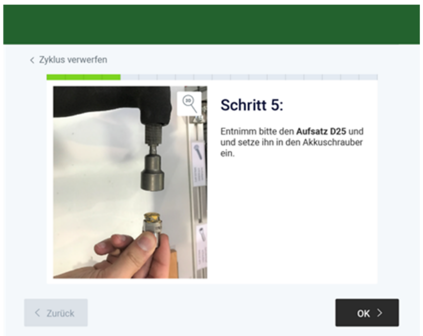
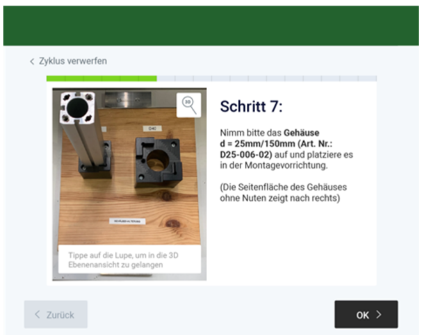
Name of the Design Element	Screenshot	(+) [1]	(−) [2]	Qualitative Analysis
Step 2		2	5	Participants criticized the amount of text as too much. The reading takes too much of their time. They would have preferred an animation or a video. Moreover, text and picture were not explicit enough; the task was not clearly described. For two of the participants, the instructions were very clear and they appreciated the many details.
Step 4		4	3	Participants liked the clear instructions and the focus on the relevant parts. It was criticized that one cannot understand the picture without the text.
Step 5		6	1	It was valued that the instructions are clear (via text and picture). One criticized that there is still too much text.
Step 7		4	3	Like before, participants liked the clear instructions, but they criticized that essential information is set in parentheses.

Table A1. *Cont.*

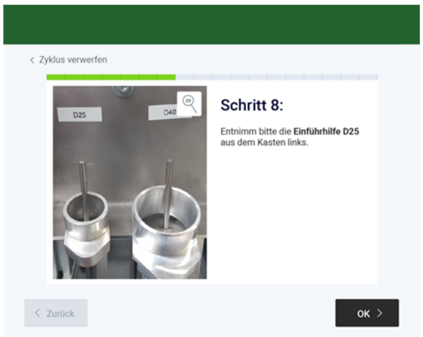
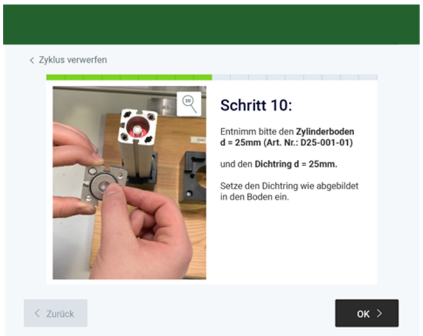
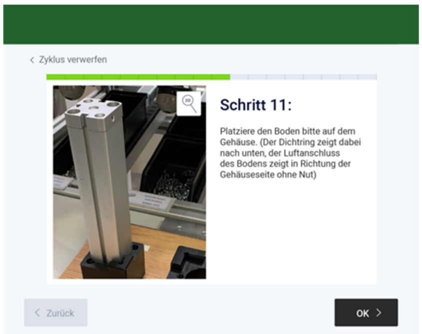
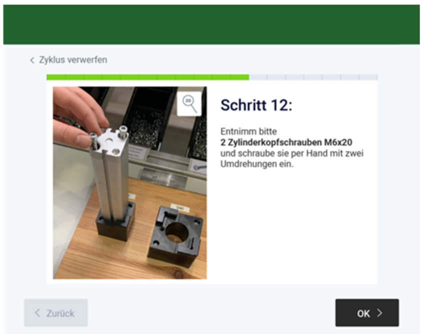
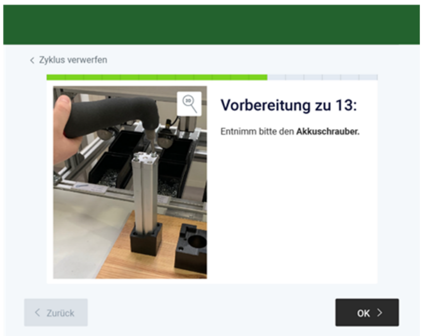
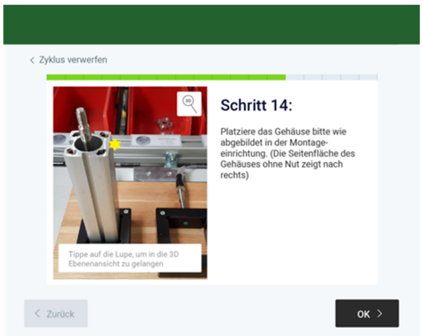
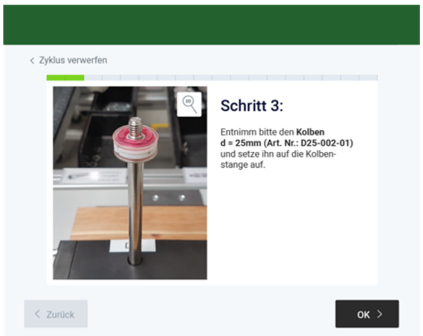
Name of the Design Element	Screenshot	(+) [1]	(−) [2]	Qualitative Analysis
Step 8		5	2	It was positively connotated that the instructions are clear and quickly read. However, it was criticized that the mentioned box was not shown in the picture.
Step 10		6	0	Participants liked the clear instructions (picture and bold print) and mentioned that the hands in the photo support the understanding. Only one person criticized a lack of focus on the component.
Step 11		4	3	On the one hand, participants appreciated the short text and the focus on the picture and found the instructions clear. On the other hand, participants did not understand the text.
Step 12		6	1	Participants found instructions clear, facilitated through the hands in the picture. One person found the provided information redundant, which could undermine the appreciation of experienced employees.

Table A1. *Cont.*

Name of the Design Element	Screenshot	(+) [1]	(−) [2]	Qualitative Analysis
Preparation to step 13		6	1	Participants appreciated the clear instructions and saw an appreciation of the employee because the screwing using a screwdriver is gentler for the worker. At the same time, one participant criticized the lack of appreciation because he or she found this information irrelevant for qualified workers.
Step 14		4	3	Participants appreciated that all information is available (picture, mark, text, 3D visualization). The negative markers referred to the star mark. Participants did not like the symbolism and did not perceive it as self-explanatory. One comment concerned with the 3D magnifier, which was not animated in the prototype.
Step 3		6	0	Participants appreciated that the important information is focused.

Note: [1] number of positive valence markers; [2] number of negative valence markers.

References

1. Burmester, M.; Zeiner, K.M.; Laib, M.; Hermosa Perrino, C.; Queßeleit, M.-L. Experience Design and Positive Design as an Alternative to Classical Human Factors Approaches. In *INTERACT 2015 Adjunct Proceedings*; Beckmann, C., Gross, T., Eds.; University of Bamberg Press: Bamberg, Germany, 2015; pp. 153–160.
2. Burmester, M.; Laib, M.; Zeiner, K.M. Positive Erlebnisse Und Wohlbefinden in Arbeitskontexten Durch Gestaltung Der Mensch-Computer-Interaktion. In *Positiv-Psychologische Forschung im Deutschsprachigen Rau—State of the Art*; Brohm-Badry, M., Peifer, C., Greve, J.M., Eds.; Pabst: Lengerich, Germany, 2017.
3. Hassenzahl, M.; Burmester, M.; Koller, F. User Experience is All There is–Twenty Years of Designing Positive Experiences and Meaningful Technology. *J. Interact. Media i-com* **2021**, *20*, 197–213. [CrossRef]
4. Zeiner, K.M.; Burmester, M.; Haasler, K.; Henschel, J.; Laib, M.; Schippert, K. Designing for Positive User Experience in Work Contexts–Experience Categories and Their Applications. *Hum. Technol.* **2018**, *14*, 140–175. [CrossRef]
5. Diefenbach, S.; Hassenzahl, M. *Psychologie in Der Nutzerzentrierten Produktgestaltung*; Springer: Berlin, Germany, 2017.
6. Laib, M.; Burmester, M.; Zeiner, K.M.; Schippert, K.; Holl, M.-L.; Hennig, D. Better Together–Unterstützung Des Positiven Erlebnisses Der Zusammenarbeit Durch Softwaregestaltung. In *Wie Menschen Wachsen—Positiv-Psychologische Entwicklung von Individuum, Organisation und Gesellschaft*; Brohm-Badry, M., Peiffer, C., Greve, J., Berend, B., Eds.; Pabst Science Publishers: Lengerich, Germany, 2018; pp. 73–90.

7. Zeiner, K.M.; Laib, M.; Schippert, K.; Burmester, M. Das Erlebnisinterview–Methode Zum Verständnis Positiver Erlebnisse: Praktische Einführung und Diskussion von Implikationen zur UX-Gestaltungspraxis. In *UP 2016*; Gesellschaft für Informatik e.V. und die German UPA e.V.: Aachen, Germany, 2016. [CrossRef]
8. Burmester, M.; Zeiner, K.M. Positive User Experience Im Kontext Smarter Arbeitsplätze. In *Workshopband der Mensch und Computer 2018*; Gesellschaft für Informatik e.V. und die German UPA e.V.: Dresden, Germany, 2018.
9. Haspel, C.; Laib, M.; Burmester, M. Positive Erlebnisse Bei Der Interaktion Mit Assistenzsystemen Gestalten–Die Erlebnispotentialanalyse. In *Mensch und Computer 2020 Workshop on «Smart Collaboration-Mitarbeiter-Zentrierte Informationssysteme in der Produktentstehung»*; Gesellschaft für Informatik e.V.: Magdeburg, Germany, 2020.
10. Fredrickson, B.L. The Role of Positive Emotions in Positive Psychology: The Broaden-and-Build Theory of Positive Emotions. *Am. Psychol.* **2001**, *56*, 218–226. [CrossRef]
11. Fredrickson, B.L. *Positive Emotions Broaden and Build*, 1st ed.; Elsevier Inc.: Amsterdam, The Netherlands, 2013; Volume 47, ISBN 9780124072367.
12. Bono, J.E.; Glomb, T.M.; Koch, A.J. Building Positive Resources: Effects Of Positive Events And Positive Reflection On Work Stress And Health. *Acad. Manag. J.* **2013**, *56*, 1601–1627. [CrossRef]
13. Hassenzahl, M. User Experience (UX): Towards an Experiential Perspective on Product Quality. In Proceedings of the 20th International Conference of the Association Francophone d'Interaction Homme-Machine, Metz, France, 2–5 September 2008; pp. 11–15.
14. Deci, E.L.; Ryan, R.M. The "What" and "Why" of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychol. Theory* **2000**, *11*, 227–268. [CrossRef]
15. Sheldon, K.M.; Elliot, A.J.; Kim, Y.; Kasser, T. What Is Satisfying about Satisfying Events? Testing 10 Candidate Psychological Needs. *J. Personal. Soc. Psychol.* **2001**, *80*, 325–339. [CrossRef]
16. Reiss, S.; Havercamp, S.M. Toward a Comprehensive Assessment of Fundamental Motivation: Factor Structure of the Reiss Profiles. *Psychol. Assess.* **1998**, *10*, 97–106. [CrossRef]
17. Desmet, P.; Fokkinga, S. Beyond Maslow's Pyramid: Introducing a Typology of Thirteen Fundamental Needs for Human-Centered Design. *Multimodal Technol. Interakt.* **2020**, *4*, 38. [CrossRef]
18. Hassenzahl, M. Bedürfniskarten. Available online: http://www.experienceandinteraction.com/tools/ (accessed on 12 September 2022).
19. Desmet, P.M.A. Faces of Product Pleasure: 25 Positive Emotions in Human-Product Interactions. *Int. J. Des.* **2012**, *6*, 1–29.
20. Klapperich, H.; Laschke, M.; Hassenzahl, M. The Positive Practice Canvas–Gathering Inspiration for Wellbeing-Driven Design. In Proceedings of the NordiCHI'18, Oslo, Norway, 29 September–3 October 2018; ACM: New York, NY, USA, 2018.
21. Zeiner, K.M.; Haasler, K.; Henschel, J.; Laib, M.; Burmester, M. Experience Categories in Specific Contexts–Creating Positive Experiences in Smart Kitchens. In Proceedings of the International HCI Conference 2018, Las Vegas, NV, USA, 15–20 July 2018.
22. *ISO 9241-11*; Ergonomics of Human-System Interaction—Part 11: Usability: Definitions and Concepts. ISO: Geneva, Switzerland, 2018.
23. Wölfle, M. Kontextsensitive Arbeitsassistenzsysteme Zur Informationsbereitstellung in Der Intralogistik. Ph.D. Thesis, Technische Universität München, München, Germany, 2014.
24. Reinhart, G. *Handbuch Industrie 4.0*; Hanser: München, Germany, 2017.
25. Lang, S. *Durchgängige Mitarbeiterinformation Zur Steigerung von Effizienz Und Prozesssicherheit in Der Produktion*; Meisenbach: Bamberg, Germany, 2007.
26. Dombrowski, U.; Wesemann, S.; Korn, G.H. Werkerinformationssystem. *ZWF* **2010**, *105*, 282–287. [CrossRef]
27. Lušić, M.; Fischer, C.; Bönig, J.; Hornfeck, R.; Franke, J. Worker Information Systems. State of the Art and Guideline for Selection under Consideration of Company Specific Boundary Conditions. *Procedia CIRP* **2016**, *44*, 1113–1118. [CrossRef]
28. Weidner, R.; Redlich, T.; Wulfsberg, J.P. *Technische Unterstützungssysteme*; Springer: Berlin/Heidelberg, Germany, 2015.
29. Sanders, A.F. Towards a Model of Stress and Human Performance. *Acta Psychol. (Amst)* **1983**, *53*, 61–97. [CrossRef]
30. Stockinger, C.; Stuke, F.; Subtil, I. User-Centered Development of a Worker Guidance System for a Flexible Production Line. *Hum. Factors Ergon. Manuf. Serv. Ind.* **2021**, *31*, 532–545. [CrossRef]
31. Gerke, W. *Technische Assistenzsysteme. Vom Industrieroboter Zum Roboterassistenten*; de Gruyter: Oldenbourg, Germany, 2015.
32. Fischer, C.; Lusic, M.; Faltus, F.; Hornfeck, R.; Franke, J. Enabling Live Data Controlled Manual Assembly Processes by Worker Information System and Nearfield Localization System. *Procedia CIRP* **2016**, *55*, 242–247. [CrossRef]
33. Kerber, F.; Lessel, P. Adaptive Und Gamifizierte Werkerassistenz in Der (Semi-) Manuellen Industrie 4.0-Montage. In Proceedings of the DeLFI Workshops 2015, München, Germany, 1 September 2015; pp. 28–35.
34. Gery, G.J. *Electronic Performance Support Systems: How and Why to Remake the Workplace through the Strategic Application of Technology*; Ziff Institute: Cambridge, MA, USA, 1993.
35. Kasvi, J.J.J.; Vartiainen, M.; Pulkkis, A.; Nieminen, M. The Role of Information Support Systems in the Joint Optimization of Work Systems. *Hum. Factors Ergon. Manuf. Serv. Ind.* **2000**, *10*, 193–221. [CrossRef]
36. Laib, M.; Burmester, M.; Zeiner, K.M. Erlebnispotentialanalyse–Mit Systematik Zu Positiven Erlebnissen. In *Mensch und Computer 2017–Usability Professionals*; Gesellschaft für Informatik e.V.: Regensburg, Germany, 2017; pp. 1–7.

37. Zeiner, K.M.; Laib, M.; Schippert, K.; Burmester, M. Identifying Experience Categories to Design for Positive Experiences with Technology at Work. In Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems, San Jose, CA, USA, 7–12 May 2016; ACM: New York, NY, USA, 2016; pp. 3013–3020.
38. Bundesministerium für Wirtschaft und Klimaschut. *Mittelstand 4.0-Kompetenzzentrum Usablity Erlebnispotentialanalyse*; Bundesministerium für Wirtschaft und Klimaschutz: Berlin, Germay, 2022.
39. Thomas, C.; Bevan, N. *Usability Context Analysis—A Paractical Guide*; Loughborough University: Loughborough, UK, 1996.
40. VanGundy, A.B. *Idea Power: Techniques & Resources to Unleash the Creativity in Your Organization*; American Management Association: New York, NY, USA, 1992.
41. Burmester, M. Valenzmethode—Formative Evaluation Der User Experience. In *Methoden der Webwissenschaft—Ein Handbuch. Bd. I Anwendungsbezogene Methoden*; Scherfer, K., Volpers, H., Eds.; LIT Verlag: Münster, Germany, 2013; Volume 11, pp. 141–160.
42. Hermosa Perrino, C.; Burmester, M. Designing for Temporal Harmony: Exploring the Well-Being Concept for Designing the Temporal Dimension of User Experience. *Multimodal Technol. Interact.* **2020**, *4*, 66. [CrossRef]
43. Burmester, M.; Zeiner, K.M.; Schippert, K.; Platz, A. Creating Positive Experiences with Digital Companions. In Proceedings of the 2019 CHI Conference Extended Abstracts on Human Factors in Computing Systems, Glasgow, UK, 4–9 May 2019; ACM: New York, NY, USA, 2019; pp. 1–6.
44. Holtzblatt, K.; Beyer, H. *Contextual Design: Design for Life*; Morgan Kaufmann: Amsterdam, The Netherlands, 2016.
45. Hassenzahl, M.; Diefenbach, S.; Göritz, A. Needs, Affect, and Interactive Products—Facets of User Experience. *Interact. Comput.* **2010**, *22*, 353–362. [CrossRef]
46. Reynolds, T.J.; Gutman, J. Laddering Theory, Method, Analysis, and Interpretation. *J. Advert. Res.* **1988**, *28*, 11–31.
47. Figma, I. Figma. Available online: https://www.figma.com/ (accessed on 19 November 2020).
48. Kohler, K.; Niebuhr, S.; Hassenzahl, M. Stay on the Ball! An Interaction Pattern Approach to the Engineering of Motivation. In *Human-Computer Interaction—INTERACT 2007*; Baranauskas, C., Palanque, P., Abascal, J., Diniz Junqueira Barbosa, S., Eds.; Springer: Berlin, Germany, 2007; Volume 4662, pp. 519–522.
49. Wiedenmaier, S.; Oehme, O.; Schmidt, L.; Luczak, H. Augmented Reality (AR) for Assembly Processes Design and Experimental Evaluation. *Int. J. Hum. Comput. Interact.* **2003**, *16*, 497–514. [CrossRef]
50. Hou, L.; Wang, X.; Bernold, L.; Love, P.E.D. Using Animated Augmented Reality to Cognitively Guide Assembly. *J. Comput. Civ. Eng.* **2013**, *27*, 439–451. [CrossRef]
51. Aehnelt, M. *Informationsassistenz Zur Kognitiven Automatisierung Manueller Montagearbeitsplätze*; Universität Rostock: Rostock, Germany, 2017.
52. Uva, A.E.; Gattullo, M.; Manghisi, V.M.; Spagnulo, D.; Cascella, G.L.; Fiorentino, M. Evaluating the Effectiveness of Spatial Augmented Reality in Smart Manufacturing: A Solution for Manual Working Stations. *Int. J. Adv. Manuf. Technol.* **2018**, *94*, 509–521. [CrossRef]
53. Tang, A.; Owen, C.; Biocca, F.; Mou, W. Comparative Effectiveness of Augmented Reality in Object Assembly. In Proceedings of the 2003 Conference on Human Factors in Computing Systems—CHI '03, Ft. Lauderdale, FL, USA, 5–10 April 2003; Cockton, G., Korhonen, P., Eds.; ACM Press: New York, NY, USA, 2003; p. 73.
54. Funk, M.; Kosch, T.; Kettner, R.; Korn, O.; Schmidt, A. MotionEAP: An Overview of 4 Years of Combining Industrial Assembly with Augmented Reality for Industry 4.0. In Proceedings of the 16th International Conference on Knowledge Technologies and Data-Driven Business, Graz, Austria, 18–19 October 2016.
55. Blattgerste, J.; Strenge, B.; Renner, P.; Pfeiffer, T.; Essig, K. Comparing Conventional and Augmented Reality Instructions for Manual Assembly Tasks. In Proceedings of the 10th International Conference on Pervasive Technologies Related to Assistive Environments, Island of Rhodes, Greece, 21–23 June 2017; pp. 75–82.
56. Minow, A.; Böckelmann, I. Beanspruchung, Objektive Leistung Und Gebrauchstauglichkeit Bei Simulierten Montageprozessen Mit Digitalen Arbeitsanweisungen. *Zent. Arb. Arb. Ergon.* **2020**, *70*, 47–56. [CrossRef]
57. Rodriguez, F.; Saleem, K.; Spilski, J.; Lachmann, T. Performance Differences between Instructions on Paper vs Digital Glasses for a Simple Assembly Task. *Appl. Ergon.* **2021**, *94*, 103423. [CrossRef]
58. Büttner, S.; Funk, M.; Sand, O.; Röcker, C. Using Head-Mounted Displays and In-Situ Projection for Assistive Systems. In Proceedings of the 9th ACM International Conference on PErvasive Technologies Related to Assistive Environments—PETRA '16, Corfu Island, Greece, 29 June–1 July 2016; pp. 1–8.
59. Watson, G.; Curran, R.; Butterfield, J.; Craig, C. The Effect of Using Animated Work Instructions Over Text and Static Graphics When Performing a Small Scale Engineering Assembly. In *Collaborative Product and Service Life Cycle Management for a Sustainable World*; Curran, R., Chou, S.-Y., Trappey, A., Eds.; Springer: London, UK, 2008; pp. 541–550.
60. Jeske, T.; Meyer, F.; Schlick, C.M. Einfluss Der Gestaltung von Arbeitsplänen Auf Die Anlernzeit Sensumotorischer Tätigkeiten. *Z. Arbeitswiss.* **2014**, *68*, 1–6. [CrossRef]
61. Watson, D.; Clark, L.A.; Tellegen, A. Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales. *J. Personal. Soc. Psychol.* **1988**, *54*, 1063–1070. [CrossRef]
62. Krohne, H.W.; Egloff, B.; Kohlmann, C.-W.; Tausch, A. Krohne_et_al_1996_Diagnostica.Pdf. *Diagnostica* **1996**, *42*, 139–156.
63. Minge, M.; Thüring, M.; Wagner, I.; Kuhr, C.V. The meCUE Questionnaire: A Modular Tool for Measuring User Experience. In *Advances in Intelligent Systems and Computing*; Soares, M., Falcão, C., Ahram, T.Z., Eds.; Springer: Cham, Switzerland, 2016; Volume 486, pp. 115–128.

64. Faul, F.; Erdfelder, E.; Lang, A.-G.; Buchner, A. G*Power 3: A Flexible Statistical Power Analysis Program for the Social, Behavioral, and Biomedical Sciences. *Behav. Res. Methods* **2007**, *39*, 175–191. [CrossRef]
65. Seligman, M.E.P.; Steen, T.A.; Park, N.; Peterson, C. Positive Psychology Progress: Empirical Validation of Interventions. *Am. Psychol.* **2005**, *60*, 410–421. [CrossRef]