Methods of presenting content in AR and optimization potential for manual workspaces

Maximilian Hofbauer[1], Bernhard Mandl[2], Martin Adam[2]

[1] University of Applied Sciences Kufstein Tirol, Andreas Hofer-Str. 7, 6330 Kufstein, Austria
Max_Hofbauer@web.de
[2] University of Applied Sciences Kufstein Tirol, Andreas Hofer-Str. 7, 6330 Kufstein, Austria
{Bernhard.Mandl, Martin.Adam}@fh-kufstein.ac.at

Abstract. This paper evaluates three different ways of providing content to shop floor workers by using Augmented Reality (AR). By using an experiment, it turns out that holograms were best accepted. In addition, significant quality improvements by using AR on a manual workplace were identified. Considering the affinity toward technology by the workers, it could be shown that the less knowledgeable a person is in technology the higher has been the benefit with AR.

Keywords: Augmented Reality, Microsoft Hololens, Worker-Assistance, Process improvement.

1 Introduction

Cost pressure, shorter order cycles and lack of qualified staff at the shop floor increase complexity in industry and in production. Augmented Reality (AR) is seen as one means to cope with these challenges [2, 6]. With the support of AR, quality of production may be proven in real-time and immediate identification of defects are possible. Optimization of workflows with AR may lead to shorter cycle times [1]. AR may also help to integrate illiterates better into work life by providing information via pictures or videos. AR can also play an important role in training. By using smart glasses during the training, the learners can choose their own speed in learning. Instead of receiving single instructions, the information can be repeated more often [3]. The last 20 years there have been several studies regarding to AR in the industrial use. Examples for AR-based instruction studies can be found in “Visual Assembling Guidance using AR” [8]. One of the key factors for breakthrough at the industrial shop floor is the high acceptance by the users. There are hardly studies to find which combine the acceptance of the user and the optimization potential for manual workspaces. The motivation is to improve the quality and time on the shop floor with AR even when the tasks are not too complex. Additionally, the worker should benefit from the improvements through a user-friendly interface. The research goal is to present possible benefits for the productivity which comply with the needs of the workers. That is the reason why this experiment was carried out and involves an application based on the user’s acceptance. After the implementation, the application is analyzed for its optimization potential for the manual workspace.

2 Experimental Settings

2.1 Experimental Environment, Selection of workplace, content and methods of AR support

To answer the research questions, several experiments have been carried out. The method of an experiment has been chosen, as research in these fields is just in its beginnings [4]. For reasons like ease of accessibility and flexibility in experimental setup, the learning factory (LEAN Lab) of the University of Applied Sciences Kufstein in Tyrol was chosen to conduct the experiments. The Lab comprises a production line and associated administrative areas. The product being produced is a clock. The production process consists of manual workstations with punching, drilling, bending, riveting, gluing, assembling and packing steps.

For the experiment, the Microsoft Hololens was used as it is currently one of the most advanced AR glasses available on the market. The wireless Hololens scans the environment and can superimpose it with high-resolution 3D-objects.

One of the first steps in the experiment was to select the proper workstation out of the seven existing to conduct the experiment. As one intention of the experiment was to identify the benefit potential of using an AR device, the workstation that causes most difficulties to training-participants was chosen. Therefore, four evaluation criteria have been defined: touch time, set up time, product quality and work-related accidents. As a result, the bending workplace was chosen as it causes most of the problems. The station involves 17 working steps which are leading to a twice bended sheet of metal with two different angles.

Next, the content of AR support was defined. This was done by using a survey among 170 former training participants in the LEAN Lab. Providing digitized work documents was their favorite choice (45 %) wherefore the AR support was orientated on that point.

After this, the methods, how to provide the content, had to be selected. Three methods of visual presentations of the content had been chosen: video, holograms and text with arrows. The video shows the recorded workflow and is embedded above the workstation. The user starts the video by gesture control. With the holograms, the worker sees step by step the virtually replicated levers, bolts, screws and other components at the right position. And in the third method, animated arrows show where to handle the machinery combined with verbal instructions.

2.2 Experiment Execution

In the first round of the experiment the acceptance of the three methods of proving content with AR was tested. Therefore 12 people were selected. None of them knew the bending process before. In order to avoid bias, the group was divided into three and each of them started with another scenario first. Besides a general introduction into

Hololens, no additional information was given. Afterwards the testers have been interviewed by using a questionnaire. Acceptance was defined by four criteria: assistance for their work, comprehensibility of content, flexibility of behavior and safety. At each question the testers had to choose between five options. Starting from total agreement to total disagreement. To have a balanced group of tech-savvy people and less technical orientated people, the testers have been selected according their job or studies. In addition to that, the people have been asked about their affinity towards technology via the questionnaire. The second experiment should reveal the improvement potentials by using AR. Another 12 test persons have been selected with the same method as in the experiment one. They have been divided into two groups. As the method of content provision, the holograms have been chosen. One group carried out the experiment with AR assistance and the second without, but with the help of written instructions. This was seen as the control group. After the experiment was conducted once, the groups changed and the experiment was conducted a second time. So both groups behaved as control groups and as AR testers. After the experiment, touch time and scrap have been measured.

3 Results and Discussion

3.1 Result Selection

In general, the provision of content by holograms was the preferred way of providing content (5 out of 12) (Figure 1). A link between technical affinity of the tester and the preferred scenario was identified, as almost all people with little technical experience prefer work instruction in text form and arrows. Due to the small number of testers, further investigations are needed.

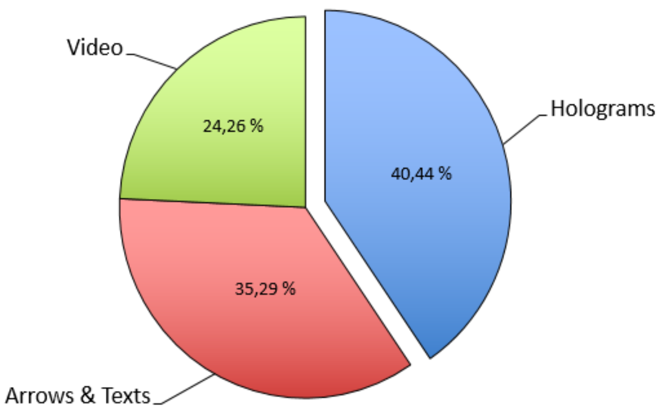

Fig. 1. Overall impression

The next evaluation criteria were classified according to the personal perception of the subjects. Half of the testers have classified the safety risk with AR as slightly elevated. Arrows with text and video showed a slight tendency toward security risk. In contrast, only one of the twelve testers considered hologram application to be hazardous. Also in terms of help and intelligibility, the holograms scenario was best rated. None of the test persons found the application to be cumbersome or irritating. This also applies to the other two scenarios. The evaluation of the flexibility reflects how strict the order of the work steps has to be carried out. The tester evaluated the applications Holograms and Arrows & Texts as largely flexible. The worst is the video. The main reason for this is that the sequence of the work steps is predetermined and cannot be interrupted or reset by voice control

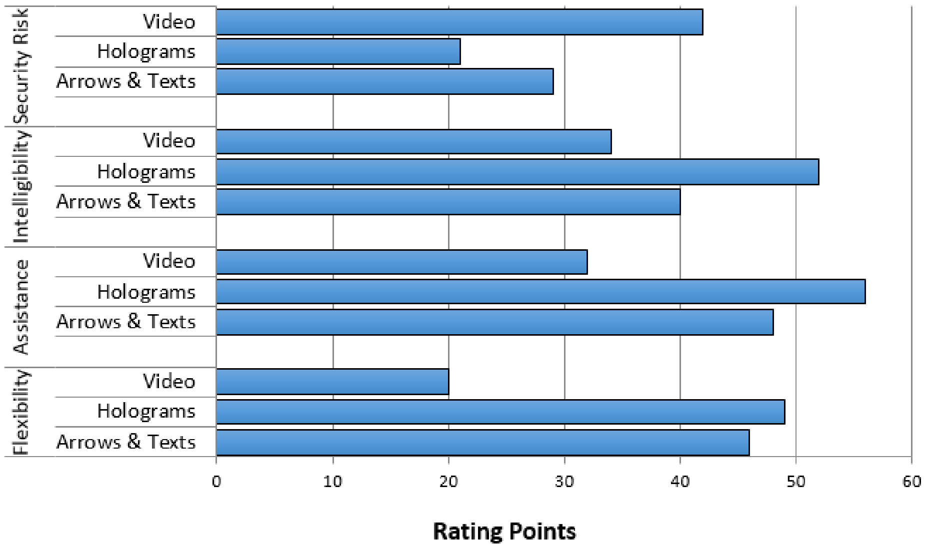

Fig. 2. AR Acceptance

Coming to the results of the second experiment about the improvement potential of AR technology, they are quite clear. The group that works with the holograms was faster than the group with only written instructions. On average, they needed 169 seconds. The control group had an average time of 184 seconds.

Putting the focus on technical affinity, there is an interesting insight. Without the support of AR, the technical related persons were 6 seconds faster on average. With the usage of AR, the needed time of technical orientated and not technical orientated persons became almost the same. (Figure 3)

The second important point in the evaluation of the experiment is quality. None of testes who used AR have produced any scrap whereas the control group had two defective outcomes. Goods were identified as scrap if the further working process was not possible anymore. A connection to the technical affinity of the test persons could not be established.

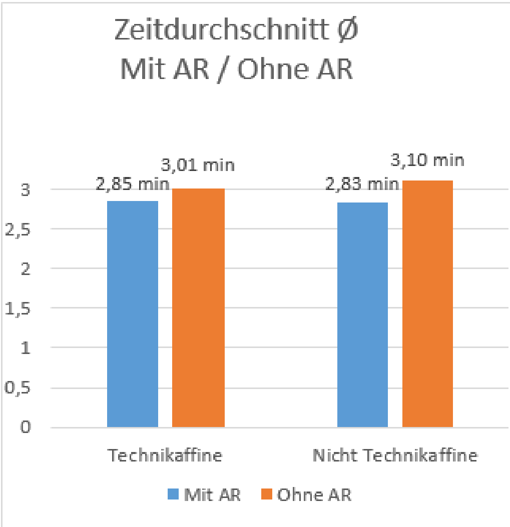

Fig. 3. Comparison technical affinity

3.2 Discussion

The discussed user acceptance is a key factor when introducing new technology. If the complexity of the application is too high, the user acceptance will be critical. That was the case for the scenario Text and Arrows. The testers prefer the hologram because the intelligibility is better. All participants of the experiment remarked that they would like to use AR instructions in future operations. That was also a result of another publication from Nilsson and Johansson (2008) [5]. A study from Baird and Barfield which is based on AR-worker assistance, indicate a big saving of time. [8]. In our experiment this result could not be totally approved. Because our testers did the work for the first time we can only say that the learning process has been improved. Another reason for that may have been the small numbers of participants or that the used working process has a too low complexity. Through the use of the AR, quality increases a lot. Compared to the group who used written working instructions, the testers who have used AR support have not produced any scrap. The paper written by Segovia with the title “Augmented Reality as a tool for Production and Quality Monitoring”, confirmed that finding [7]. The last finding regarding the technical orientation of the users showed that the less a worker is affine toward technology, the more AR helps in faster providing a result.

4 Conclusion

After evaluating the experiment, a lot of new insights arise. Already by discussing a suitable scenario, interesting results have been achieved. On the one side the testers wanted clear and understandable instructions. On the other side they rejected a strict detailed guideline to completing the working steps, as this hinders flexibility. This could lead to a guideline in handling AR: AR should remain a support and not reduces the flexibility of the worker. What could have been shown clearly that as a means of providing content, holograms have been accepted best. But technological affinity had an influence on it. That could lead to another guideline: Technological affinity of the workers needs to be taken into consideration. A clear result was that by the use of AR the learning time for a new job was reduced and also scrap rate dropped heavily. Also here, technological affinity of the workers matters. People who had less affinity towards technology had higher rates of improvement by using AR. For the future, this experiment can be the base for large quantitative test runs which would be useful to confirm the knowledge acquired in this experiment.

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