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Augmented Reality as a tool for providing informational content in different production domains

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Abstract

Augmented Reality (AR) is a versatile tool for enriching the real world with digital content. By presenting information virtually on head-mounted devices, the user can perform different tasks hands-free. Despite the benefits of AR, this kind of information representation is a niche application in the production industry. It is not yet clear, whether the reasons are about the available AR technology or about level of acceptance by the user. The aim of the presented paper is to investigate the potential of AR in production applications. Three different use-cases generated data regarding the acceptance of the user by applying different types of AR support, influence of different AR hardware, and the potential of AR support in different production-related disciplines (manufacture, assembly, and maintenance). The study revealed that the impact of AR increased with the required time for the task. In addition, benefit of AR was related to the technological skills of the user. However, AR seems to enable a better task time planning which is reflected by the smaller standard deviations of required time in all settings.

Keywords: Augmented Realitiy; Production; Manufacturing; Assembly; Maintenance

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1. Introduction

Recent developments in production showed that work would become more flexible in different dimensions: local, temporal and contextual. In addition, flexible production is required for fulfilling the demand of small lot sizes combined with complex products, which results in increasingly agile processes [1,2]. Thus, there is unanimous agreement in theory that interface competencies and the ability to solve abstract situational problems are gaining in significance [3,4]. Employee training with technologies like AR should be placed in a scenario that resembles the daily production environment. Thus, learning factories may provide the adequate training side. In addition, the technological integration of AR systems can be developed and tested in the learning factory to optimize the system for finally implementation in a real-world production scenario [5]. The application of AR in learning factories was highlighted in recent years [6–8] which might emphasize the potential of AR as a method for delivering informational content in a production setting.

Augmented Reality (AR) provides the opportunity to provide informational content on-side, on-demand, and side specific by enriching the real world with virtual content [8]. The implementation of AR, resulting in altered approaches for workplace training and working, implies a paradigm shift for the employees, which is why a comprehensive employee integration in the implementation process of the AR solution is recommended [8].

The aim of the paper is to investigate the benefit of AR support in three different production areas: manufacturing task, assembly task, and maintenance task. The influence of AR was determined in duration of the task, flexibility of the support, ergonomics of the device, and flexibility of performing the task. The control group received written instructions for completing the different tasks.

2. Experimental Setups

In three different experimental setups, the impact of AR on three different production processes was investigated. The first production process represented a manufacturing task, the second an assembly task, and the third task investigates the potential of AR of a maintenance task.

2.1. Experimental Setup 1 – Manufacture

To investigate the potential of AR in a manufacturing process, participants had to follow a well-defined bending process. The process consisted of the set-up of the bending machine, inserting the raw material (piece of metal sheet), and the bending of the metal sheet to a defined bending angle. The control group followed written instructions, the AR group was guided through the process by a holographic illustration of the process steps. In a preliminary study, the holographic representation received the highest acceptance in contrast to an instructional video, and overlaying text-based instructions [5]. In Table 1, details about the test procedure are listed.

Table 1. Experimental Setup 1.

Number of participants	12
Female	3
Male	9
Groups	2
Used Process	Bending
Technology	Hologram
AR Device	MS Hololens

The assessed parameters for measuring the potential of AR were process time and the successful completion of the bending process. An additional questionnaire assessed the participant's affinity to technology, clarity of the instructions, ergonomics, and flexibility in execution of the task.

2.2. Results Experiment 1 – Production

The experiment showed that the AR group were 17 % faster in completing the task then the control group with textual instructions. The difference in the duration for the task between both groups was not significant. Comparing the product quality between both groups, no significant difference was detected.

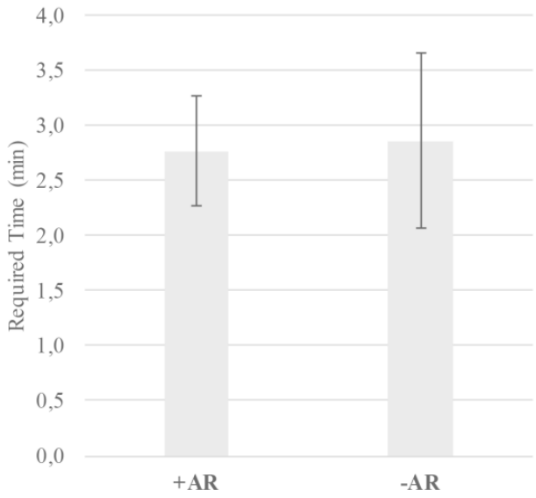

Fig. 1. Required time for a production task. The impact of AR support onto time was tested on a bending process. Participants with AR support (n=6) and participants with textual instructions (n=6) were tested.

The clarity of the instructions was higher for AR transported instructions than for text-based instructions. Ergonomic aspects were comparable for both groups, wearing the AR device was recognized as comfortable which might by biased by the short duration of the task.

2.3. Experimental Setup 2 – Assembly

In this experimental setup, the participants had to assemble a technical product (flashlight). Participants of the AR group were guided through the process by an instructional video displayed on a head mounted display. The control group received written instructions for completing the assembly task [9]. Further details about the experimental setup is shown in Table 2.

Table 2. Experimental Setup 2.

Number of participants	26
Female	9
Male	17
Repetitions	1
Used process	Assembly
Technology	Video
AR Device	Realwear HMT-1

For analysing the data, the technological affinity of the participants was assessed by an interview. In addition, the clarity of the instructions, ergonomics, and flexibility of task execution were recorded.

2.4. Results Experiment 2 – Assembly

The experiment exhibited that the group with AR support was 11 % faster in assembly than the control group. The mean duration of the assembly process with AR support was 8.34±2.89 min compared to 9.29±3.45 min of the control group. Analysing the gender aspect it was revealed that female participants completed the task in 9.11±3.03 min when supported by AR whereas female participants of the control group completed the task in 11.28±3.50 minutes. Male participants completed the task in 7.86±3.03 min (+AR) and 8.40±3.25 min (control group), respectively. Thus, female participants reduced the duration of the process for 2 min whereas male participants reduced the duration of the task only for 0.54 min when supported by AR. The reduction in required time was observed in all groups regarding the technological affinity. Only participants with medium technological affinity seemed to not benefit from AR support.

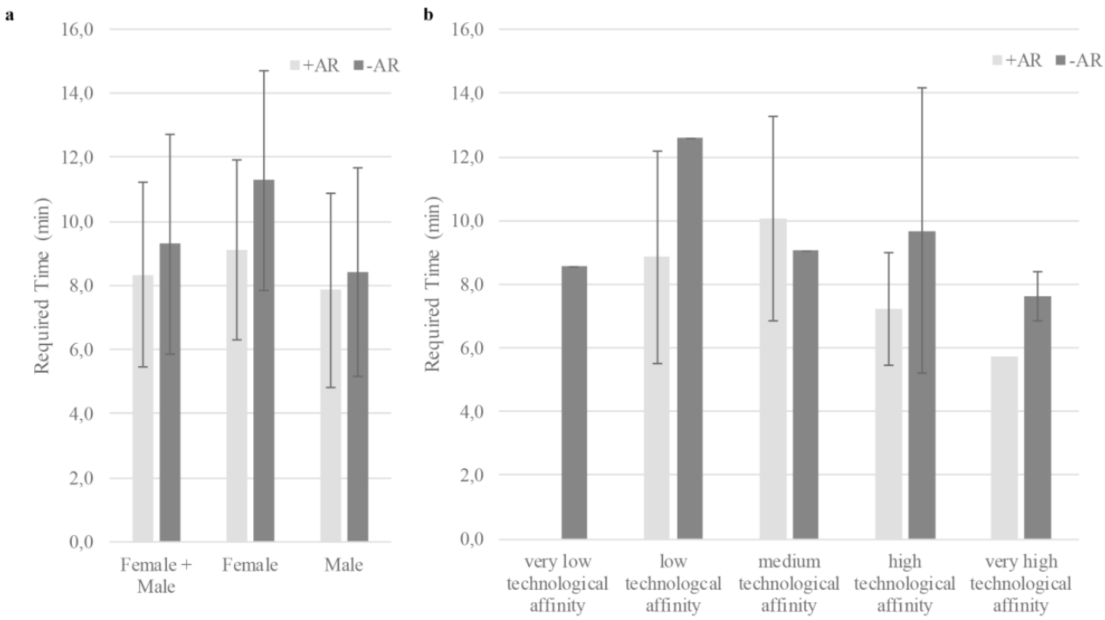

Fig. 2. Required time for an assembly task. The impact of AR support onto time was tested on an assembly task of a flashlight. Participants with AR support (n=13) and participants with textual instructions (n=13) were tested. In (a) the required time for completing the task is shown for all, for female, and for male participants. The graph in (b) highlights the required time for task completion in dependency of the technological affinity of the participants.

The clarity of the video-based assistance displayed by the head-mounted device was higher than the text-based instruction of the control group. The ergonomics of the head-mounted device was unsatisfactory.

2.5. Experimental Setup 3 – Maintenance

The third experimental setting investigated the potential of AR for completing a maintenance tasks. The AR group received instructional videos on a head-mounted display. The control group followed textual instructions for completing the maintenance task [10]. Details about the experimental setting are shown in Table 3.

Table 3: Experimental Setup 3

Number of participants	25
Female	6
Male	19
Repetitions	1
Used process	Maintenance of 3D Printer
Technology	Video
AR Device	Realwear HMT-1

The goal of the maintenance task was to un-clogg the nozzle of a fused deposition modelling (FDM) printer [11]. The participants had no former knowledge of the process or the used FDM printer. All participants were introduced to the AR device shortly prior to the maintenance task. The assessed parameters of the test were time required and a final questionnaire for sampling user feedback. The final questionnaire asked for clarity of the instructions, flexibility, and ergonomics of the AR device.

2.6. Results Experiment 3 – Maintenance

The time required for the maintenance process was comparable between the two groups. The mean duration of the group with AR assistance was 12.61±1.65 min and 14.16±2.48 min, respectively. The standard deviation of the required time was narrower for the AR group than for the control group. Gender aspects were not included in the interpretation of the study due to only one female participant in the AR group.

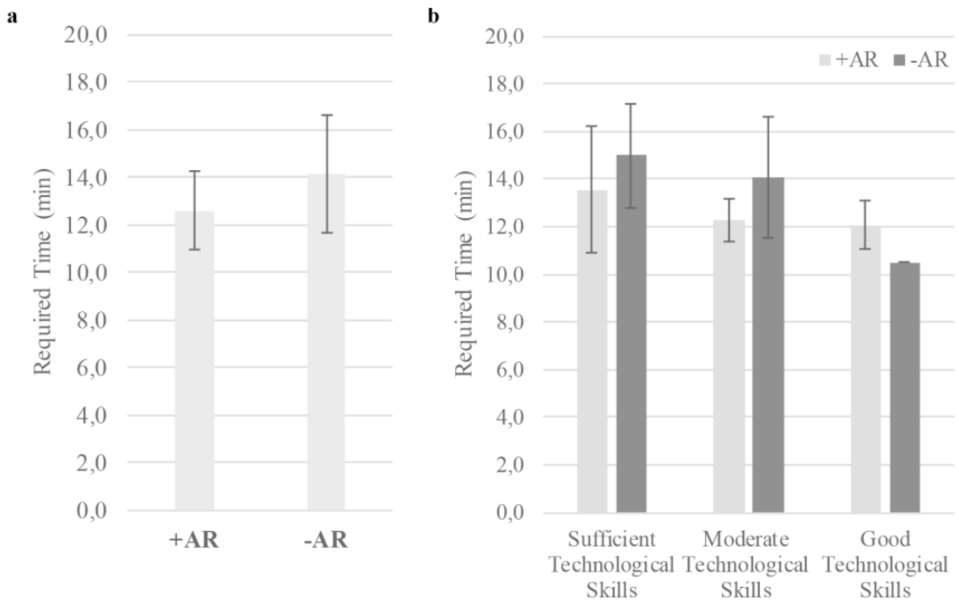

Fig. 3. Required time for a maintenance task. The graph in (a) shows the impact of AR on the required time to complete a maintenance task. Participants with AR support (n=13) and participants with textual instructions (n=12) were tested. In (b) the required time for the task is shown in dependency of the technological skills of the participants.

The clarity of the instructions were experienced as better for AR than text-based instructions. The ergonomics of the used system was experienced as moderate due to difficulties in adjusting the head-mounted device correctly.

3. Conclusion

Augmented reality applications represents a promising approach in delivering content in production related disciplines. The reduction in process time when AR is used as support is non-signifiant in comparison to the control group. However, participants lacking technological skills benefited from AR support in accomplishing assembly and maintenance task. Thus, AR revealed as a method in transporting informational content for accomplishing an individual complex task. As we could demonstrate, participants with low technological skills were able to complete the presented tasks successfully, thus, technological skilled people can fulfill tasks with high complexity when they are supported by AR. In addition, the support by AR enabled a more precise forecast of required time in all three disciplines. Consequently, task management may benefit from AR by enabling reliable task planning independent of the worker's skills.

Ergonomic aspects were experienced critical in the assembly and in the maintenance task. The manufacturing task did not influence the ergonomics of the system. The reason might be in the different systems (manufacturing – MS Hololens, assembly and maintenance – HMT-1) and in the duration of the tasks. The manufacturing task took 3 min whereas the assembly task took 8 min and the maintenance task 12 min. The duration aspect may also influence the temporal benefit of AR which might be minor for short-lasting tasks and greater for longer tasks.

The presented data highlights the universal benefits of AR in different production disciplines. Gender related aspects of AR impact was also revealed, showing that female participants exhibited the minor higher benefits in AR support. These finding are still preliminary and underscores the need for further studies about AR in the context of production. Especially, gender aspects have to be included in future experiments.

References

[1] N. Slack, Flexibility as a Manufacturing Objective, Int Jrnl of Op & Prod Mnagemnt 3 (1983) 4–13. https://doi.org/10.1108/eb054696.
[2] A. Sethi, S. Sethi, Flexibility in manufacturing: A survey, Int J Flex Manuf Syst 2 (1990). https://doi.org/10.1007/BF00186471.
[3] C.B. Frey, M.A. Osborne, The future of employment: How susceptible are jobs to computerisation?, Technological Forecasting and Social Change 114 (2017) 254–280. https://doi.org/10.1016/j.techfore.2016.08.019.
[4] A. Botthof, E. Hartmann (Eds.), Zukunft der Arbeit in Industrie 4.0, Springer Vieweg, Berlin, 2015.
[5] M. Hofbauer, B. Mandl, M. Adam, Augmented Reality - Von der Forschung in die Industrie, in: H. Orsolits, M. Lackner (Eds.), Virtual Reality und Augmented Reality in der Digitalen Produktion, GABLER, [S.l.], 2020, pp. 237–262.
[6] D. Sonntag, G. Albuquerque, M. Magnor, O. Bodensiek, Hybrid learning environments by data-driven augmened reality, Procedia Manufacturing 31 (2019) 32–37. https://doi.org/10.1016/j.promfg.2019.03.006.
[7] C. Hofmann, T. Staehr, S. Cohen, N. Stricker, B. Haefner, G. Lanza, Augmented Go & See: An approach for improved bottleneck identification in production lines, Procedia Manufacturing 31 (2019) 148–154. https://doi.org/10.1016/j.promfg.2019.03.023.
[8] S.R. Sorko, M. Brunnhofer, Potentials of Augmented Reality in Training, Procedia Manufacturing 31 (2019) 85–90. https://doi.org/10.1016/j.promfg.2019.03.014.
[9] B. Wohlschläger, Der Einsatz von Augmented Reality in der Produktion am Beispiel des Montageprozesses eines Demoobjektes. Bachelorthesis, Kufstein, 2018.
[10] L. Von Czettritz, Anwendung von Augmented Reality in der Lernfabrik der FH Kufstein am Beispiel 3D Drucker. Bachelorthesis, Kufstein, 2018.
[11] Ultimaker, How to apply the Atomic Method, 2020, https://ultimaker.com/en/resources/19510-how-to-apply-atomic-method.