Enhancing workplace learning by augmented reality

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ABSTRACT
The aim of the poster is to highlight the opportunities of augmented reality (AR) for enhancing workplace learning. The poster presents a concept for workplace learning by incorporating the digital twin (DT) concept to support the operator during the machining task. By providing in-depth information about the workpiece and the machine, the operator will be supported in fulfilling the proposed task in-time and at the defined level of quality. Preliminary data indicated, that visual support by AR technology reduces the processing time of simple tasks. The challenges when applying AR technology to industrial tasks were investigated in an additional case study.

Author Keywords
Digital Twin, Augmented Reality, Workplace Learning

ACM Classification Keywords
H.5.1 [Information interfaces and presentation]: augmented reality

INTRODUCTION
In the context of digitalization, accelerated workplace learning is the basis for the implementation towards lot size one. The challenge of an accelerated workplace learning system, is to provide information about an object's fate in time and by an appropriate sensory channel. Augmented reality systems utilize an intuitive approach by providing information visually to the operator.

The digital twin describes the virtual representation of an existing object. In the context of production systems, the digital twin can represent a machine enabling the operator to get information about the machine conditions which may be not accessible by the human senses alone. Consequently, the first digital twin may be the first design drawing done by a computer aided design system. Consequently, the digital twin enables a consistent traceability for quality issues, as a simulation platform for predicting implications of future stresses and strains, to monitor the real-time status for planning maintenance tasks, etc.

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The centerpiece of the workplace learning concept is an iterative approach, based on the concept of action-based learning [1].

The aim of the poster is to display the theoretical structure of this workplace learning concept.

FOUNDATION
The workplace learning model will be designed based on an extensive literature research about digital twin, feedback strategies, and communication principles. In addition, the ability of augmented reality in a manufacturing context will be highlighted by two case studies.

Digital Twin
The digital twin concept was first used in 2002 in a presentation held by Grieves at the University of Michigan. By equipping the real object with sensors, real-time data about usage are recorded and transmitted to the digital twin. Beside tracking the current status of a given object by observing the digital representation, the DT concept enables also prediction of future behavior. The DT concept has been described as a key concept related to the digital factory in the context of industry 4.0 [2] as well as cyber-physical systems in the context of the Internet of Things [3].

Augmented Reality
Augmented Reality – the possibility to augment the reality with computer generated information [4] represents an opportunity to visualize complex data like instructions to workplaces or relevant information concerning security issues. Another interesting statement that also supports the usage of AR is the following from Dubois and Nigay in [5]:

> *"The growing interest of designers for this paradigm is due to the dual need of users to both benefit from computers and interact with the real world" [5]*

One of the biggest benefits that are going along with smart-glasses is the hands-free handling. Recent devices like Microsoft HoloLens and Google Glass are controlled by voice command or gesture control.

WORKPLACE LEARNING CONCEPT

The workplace learning concept consists of the four phases: plan, do, check and act.

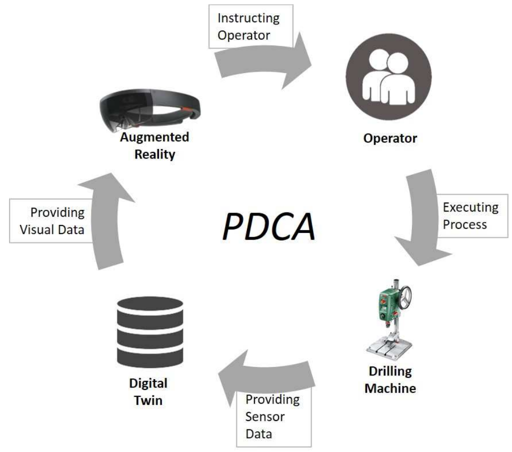

Figure 1: Workplace learning concept based on the PDCA-Cycle for Continuous Improvement – Example: Drilling

At the time the workpiece arrives at the station the operator receives the machining instructions visually. By accessing the digital twin of the object, actual data about the workpiece is delivered to the workplace station. These data may include actual dimensions, actual positon of previous working steps (e.g. position of drilled holes). The working instructions are adapted to the actual status and are delivered to the operator by visual means. *Do* - Virtual overlays guide the operator through adjusting machining parameters and positioning of the workpiece within the machine. Finally, the operator initializes the machining. After finishing the machining, the processed object is controlled again by visual means. This introduces the third phase *Check*. The digital twin of the object is updated by communicating the processing parameters of the occurred process. *Act* - Analyzing process parameters like process duration, quality etc. enables the learning system to adapt the feedback to the operator. Further, early machine-related incidences (e.g. abrasion of tool) may be extracted from the gathered data. Thereby supporting the operator to achieve the required level of quality.

CASE STUDY RESULTS

To test the prerequisites which are data provision by visual means of the workplace learning concept, two preliminary field-tests have been realized. The first case study investigates the effect of AR on workplace learning. The second case translates the findings of the laboratory stage to an industrial application. Here, the AR system is used to support the operator in setting-up a production line.

Case Study – Learning Factory

The learning factory case study examined the effect of a step-by-step guidance on learning speed of unexperienced operators. At the LEANLab of the University of Applied Sciences Kufstein, one manufacturing process (bending of a piece of sheet metal) was selected as experimental setting. The operator was confronted with visual instructions for each working step. The time for completing the task was recorded and compared to a control group without the support of augmented reality guidance.

Case Study - Industry

Based on the findings of the potential of augmented reality in supporting the operator, a complex task of a given industrial interrogation was chosen to prove the scalability of the AR system. The challenge of this task was the visualization of setting-up a machine for a production process. This task involved the placement of visual overlays in a larger three-dimensional space including various perspectives [6]. By using a marker-based tracking approach it was possible to resign voice commands. Consequently, the operator can focus on the process without the need to shift attention for activating the next step of the process.

DISCUSSION

We could show, that augmented reality is an intuitive feedback channel for supporting operators in various scenarios. The first case study revealed, that the application of AR for guiding unexperienced operators through an even simple task results in a reduction of process time compared to a control group. The scalability of the system into industrial task is possible but requires task-specific adjustments. By including information about the object using its digital representative, the operator might gain further support in reaching the required level of quality.

CONCLUSION

Augmented reality in combination with the digital twin methodology is a disruptive approach in workplace learning. Ongoing technological evolution of AR-systems will further improve the effectiveness of the proposed workplace learning concept.

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