Seamless Learning in the Production

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Abstract

Production SMEs in the automotive value chain/network are increasingly confronted with a serious number of specific requirements and regulations. Compared to large enterprises especially blue-collar workers have to deal with shared responsibilities at the shop floor in order to fulfill the different tasks they have to perform. There is a great need of an overall on-the-job knowledge, available in the right time at the right place. In this case workers need seamless learning in real-life situations ("in-situ", pervasive learning), a field which is still emerging, especially in settings of production SMEs. This industrial challenge gives rise to the following research questions: How need such learning services to be designed in order to achieve a high acceptance rate by learners and/or trainers? What are multimodal input and output interactions as well as interfaces suitable for HCI concepts for learning? How can contextual data be applied for high efficiency and efficacy of context-aware pervasive learning? Therefore we examine a context-of-use scenario in a metal forming SME for the purpose of developing a mobile pervasive learning system.

1 Introduction

Combining learning environments with work environments for training provides a powerful method for continued education in a Smart Factory. A new strategy in learning for production workers should be investigated by establishing and transferring best practices for the design and delivery of learning experiences made possible by a SME as a leading role. High skilled workers will be equipped with AR-capable mobile devices to generate specific, useful and high quality multimedia content to successfully receive and also to transfer tacit knowledge and learning matters on a specific (challenging) task, while conducting it in real-life settings. Thinking aloud what the worker does and why will generate a new atmosphere for low skilled workers to successfully learn from this content by using the learning platform. The intent is to combine learning content with additional information from the machine on the shop floor to create a new learning environment. Not only the way of content generation, but also the nature of learning content should constitute advancements over the state of the art. The project consists of four goals which will be applied to measureable objectives. One

Veröffentlicht durch die Gesellschaft für Informatik e. V. 2017 in
M. Burghardt, R. Wimmer, C. Wolff, C. Womser-Hacker (Hrsg.):
Mensch und Computer 2017 – Workshopband, 10.–13. September 2017, Regensburg.
 https://doi.org/10.18420/muc2017-ws04-0397

measureable objective out of the goals targets to develop and demonstrate an on the job learning environment for shop floor workers using rich media through the smart factory FACTS4WORKERS solution, which should be especially valuable for the constituted SME. The FACTS4WORKERS solution was built in the EU H2020 project called FACTS4WORERS in which we build a software solution to support the worker in his/her daily work to improve worker satisfaction and productivity.

The suggested solution should enable the users to go through a seamless learning (SL) experience. A seamless learning space is defined as a space where learners can decide in which learning context they perform the learning and training situation. Contexts could be formal or informal and, additionally, learners can decide if they learn individually or in a social learning environment (Chan, T. W. et al., 2006).

2 Approach

At first, a maintenance process (lens cleaning operation) at EMO Orodjarna was investigated to gain information about a real world use case. After the use case was analyzed a concept for a framework for mobile learning environments was derived and adapted to fit into the existing IT infrastructure and the existing FACTS4WORKERS solution.

2.1 Context-of-use EMO Orodjarna

EMO - Orodjarna d.o.o. (EMO) produces tools for metal stamping (progressive and transfer tools). The company's main customers are the automotive and aviation industries and their suppliers to which EMO delivers tools for large presses. Most of the tools' components are manufactured in-house. These components are later assembled into the final product (progressive and transfer tools) that is delivered to the customer.

Highly skilled workers utilize a large machine park to produce parts according to specifications. Each worker is assigned to a specific machine that he operates. He has detailed and specific knowledge of this machine and is generally the first one to realize that there are problems or deviations. Currently, a special maintenance team, which periodically checks the machines and does repairs whenever necessary, does the maintenance and repairs whenever necessary. The worker just does smaller maintenance jobs, such as topping up the cooling liquid, or changing an air filter. The aim of this context-of-use is to upskill the worker so that he can also perform preventive maintenance tasks on his machine in order to prevent damage and can thus increase the overall machine utilization by making the machine more durable.

Use case description

These training courses for the operator on the laser cutting machine contain a comprehensive combination of lectures to cover from basic machine operation procedures as well as CNC programming and maintenance procedures. The main training course includes theoretical knowledge, practical training and also includes the core of knowledge which is fundamental for being a fully qualified laser machine operator. The daily work of a laser machine operator begins with the quick check of the basic machine points and then he proceeds with the cutting operations according to the plan. During his work the operator deals with all possible errors which appear in the work process.

The operator on the laser cutting machine is in the middle of an unexpected problem that requires a maintenance procedure on the laser cutter. A parabolic mirror has become dirty and must be cleaned. The machine has triggered a corresponding warning. This requires that the operator must partially disassemble the laser head.

The classical cleaning process of the laser mirror is:

- stop the machine,
- shout down the machine,
- uncouple DIAS cable,
- remove the safety cap, unscrew the screws on the bottom part of the laser head,
- remove the lens screw and pull out the part with the lenses,
- carefully remove the lens from the frame,
- prepare the cleaning set for lenses,
- clean the lese with the liquid and wipe it with the paper,
- check the condition of the lens,
- carefully assembly the lens into the frame,
- return the assembled lens to the laser head,
- couple the cables,
- turn on the machine.

Possible future improvements could be to guide the worker through the maintenance process by offering him the right amount of information when he needs this to undertake an activity. This can be done by means of IT solutions tailored to this environment and to the worker's knowledge demands. This process includes a mobile device that helps during maintenance activities by providing specific instructions and guidelines.

When the laser cutter issues a warning that the parabolic mirror has to be cleaned, the operator on the laser notices this warning, takes out the smart glasses system and looks up the error in the database. This normal, preventive maintenance procedure prescribed in the machine's handbook is not a big deal. He quickly retrieves the necessary procedure from the glasses. A detailed step-by-step guide, which is prepared as part of the preventive maintenance routines, gives the worker directions that he can manage to repair the machine on his own.

2.2 Framework for Mobile Learning environments

Many different learning situations will take place at EMO - Orodjarna. Because of that we apply and adapt the mobile learning framework of Frohberg et al. (2009) which is demonstrated in Figure 1. We consider a training plan which consists of three stages of education. These stages are divided into four different contexts that are the independent context, the formalized context, the physical context and the socializing context.

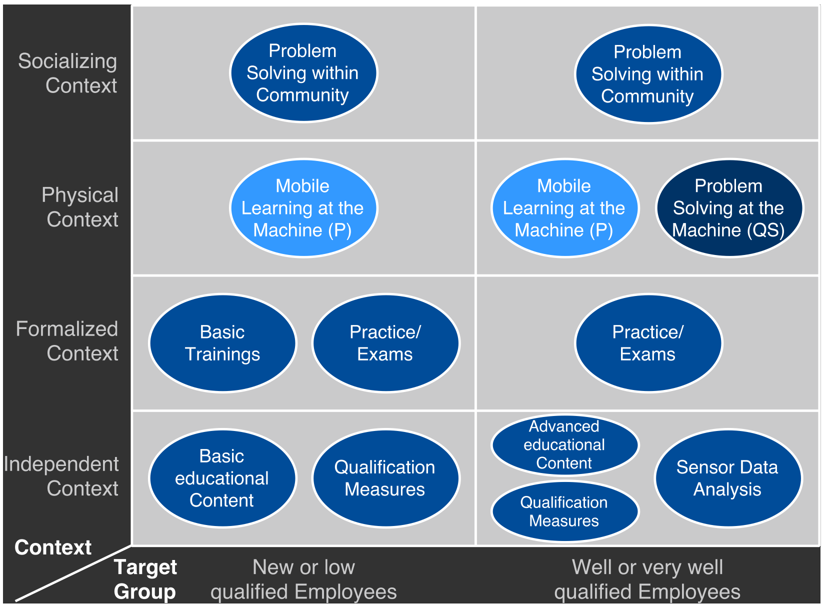

Figure 1: learning arrangements

By the independent context is meant that the learner has no special reference to the current environment. The formalized context is a place where organizational functions take place which synchronizes a group of learners (e.g. classroom situations) within the same context. The physical context demonstrates a place (e.g. the workplace on the shopfloor) where the learner stays and whose context is relevant to him. And the socializing context describes the permanent interpersonal relationship between learners (Frohberg et al., 2009).

In order to develop a mobile learning solution for shop floor workers it is necessary to gather requirements of blue-collar workers. In general the functionalities should serve the several contexts stated above. By using a smart device (in this case the Recon Jet™ smart eyewear) the worker should be able to record video footage while performing specific tasks to provide his knowledge to other workers. The main purpose to use this application is to consult teaching content out of the different stages of education. It is necessary to playback videos which are dedicated either to learn new content or to refresh and improve skills and knowledge. In this case the usage of the device should be smooth and easy and should not constrain the worker within the learning situation. The environmental issues such as background noise, lighting, etc. are important aspects that have to be considered in choosing the right device and developing the application. The workers mentioned that they like to have the possibility to give feedback of learning videos. They want to rate videos after watching them, make recommendations and assess the quality of the learning content. If there are no learning videos for a specific context available there should be the functionality of getting in contact with knowledge carriers fast and easy. This is important in learning situations that take place directly at the machine during the production process. Additional to these functionalities a video editor which runs on a tablet or a desktop computer should also be available.

Requirements of the smart glasses user interface (UI), suitable for learning, were already investigated in our other study. We developed a project-based learning scenario in which the users had to construct, produce and assemble a planetary gear with Lego® Technic. The assembly was recorded with the smart glasses to use these videos as training material for others. The second approach was to use a pre-rendered assembly animation as training material. In a qualitative study the effectiveness of such training material was compared and evaluated by seven users to get a first qualitative feedback of the smart glasses app. The following requirements emerged from this user study (Spitzer & Ebner, 2017).

Table 1: Emerged requirements from qualitative smart glasses app study (Spitzer & Ebner, 2017)

Requirement	Description
REQ1	The app needs an easy pause functionality to pause the training situation.
REQ2	The different parts of the training situation should be easily distinguishable for instance with sequence numbers displayed.
REQ3	The users should be able to jump between sections easily.
REQ4	Users should be able to control the speed of the training videos.
REQ5	The user input should not distract the user from performing the training and learning situation. Hand gestures should be tested because then the users don't have to put their hands to the smart glasses' touchpad, which could influence the learning situation.
REQ6	Inactive parts/areas of the video should be grayed out to let the user focus on the current training and learning step.

3 Technological Solution

The Smart Glasses App is coupled with the already developed FACTS4WORKERS infrastructure. Figure 2 shows the details of the FACTS4WORKERS architecture. The ReconJet Smart Glasses accesses the Backend with a REST interface through a reverse proxy implemented with NGiNX. The whole software architecture was built with Docker which allows splitting the whole systems in smaller building blocks. This approach reduces the complexity and allows the development of each of the building blocks separately. The building block's complexity is then reduced but moves to the interfaces.

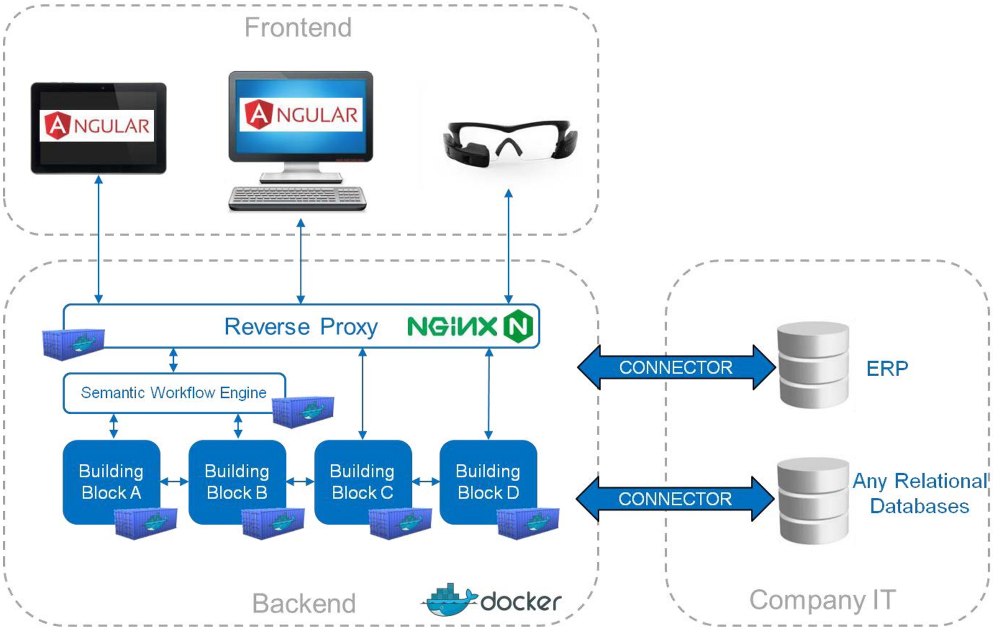

Figure 2: EMO software architecture, adapted from the generic FACTS4WORKERS software architecture (FACTS4WORKERS System Architecture, 2017)

4 Summary

We introduced a learning framework to support the worker during his/her daily life. We described in detail a maintenance process at the industry partner EMO which we will then use to evaluate the framework. A smart glasses app is in development which will be implemented according to the experiences we made in previous studies. The whole framework supports seamless learning and the worker should be able to choose the appropriate learning context.

5 Acknowledgements

This study has received funding from FACTS4WORKERS – Worker-centric Workplaces for Smart Factories - the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 636778. The authors acknowledge the financial support of the COMET K2 - Competence Centers for Excellent Technologies Programme of the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT), the Austrian Federal Ministry of Science, Research and Economy (BMWFW), the Austrian Research Promotion Agency (FFG), the Province of Styria and the Styrian Business Promotion Agency (SFG).

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