Social Augmented Learning

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Abstract— **This article provides an insight into the design and implementation of a training application enabling trainees to explore complex machines via 3D visualization and Augmented Reality, and to work on learning contents together. The application has been developed within the Social Augmented Learning project and supports an effective use of mobile devices, Augmented Reality and communication via social networks for professional training. It also supports Trainers in easily creating new learning content. First experiences in the print and media sector prove the applicability of this application and demonstrate the potential of the digitally extended learning environment.**

***Index Terms*—electronic learning, educational technology, augmented reality, social media, social learning**

I. Introduction

The Social Augmented Learning project focuses on an interdisciplinary approach to combine the fields of social, mobile, and augmented learning into a new, technology-supported way of teaching and learning. Within this context, a learning application has been developed and implemented, as well as tested and evaluated for vocational training for the *media technologist for print* profession.

This profession is losing more and more of its attractiveness due to the difficult economic situation of the sector [1], [2]. At the same time, it is characterized by an increasing complexity resulting from technological progress and converging professional fields. In this course, the operation of printing is of great relevance: highly precise instruments allow only tiny tolerances at high processing speeds in order to reproduce a perfect print image. During professional education, the operation of these machines can no longer be taught in a sufficient way, as trainees only get to know the machines available in the respective professional school and company, but in their later professional lives have to work with a variety of machine configurations.

On the other hand, modern printing machines are normally closed systems, like black boxes. As processes taking place on the inside and cause-effect relationships are not directly comprehensible, learning at the machines becomes more and more difficult. This also leads to the fact that the potential of modern machines is no longer completely utilized [3]. Furthermore, even smaller maintenance tasks have to be carried out by the manufacturer.

Conventional learning devices, such as books, scripts, or figures, are no longer suitable for the descriptive representation of complex relationships and mechanisms. Whereas in the past, practical teaching was possible, e. g. by opening or partially dismantling the respective machine during operation, today this might not be the case and new ways to do so have to be found.

Therefore, the need for innovative methods for knowledge transfer is great in order to adapt the level of education and training to technical progress in the sector.

II. Related Work

Augmented Reality is defined as the extension of reality by adding virtual objects. It is characterized by the three-dimensional reference between virtual and real objects, as well as by interaction in real time [4]. In [5] the use of AR systems in education is subdivided into 5 important subsections:

1. AR books: By implementing AR markers into common books, texts and illustrations can be complemented with dynamic and interactive contents via smartphones or tablets [6]. Several tests have already indicated a better understanding of contents, as well as a higher acceptance, even without preliminary instruction [7].

2. AR games: These lead to an increased joy of learning and encourage the learner to interactively deal with abstract or complex contents via trial and error. Various studies show that AR games may significantly increase the speed of learning, as well as the enthusiasm of the learners [8].

3. Exploration-based learning: AR technology allows the annotation of different objects or places, like excavations [9], with additional digital contents. The learner does not know which objects are connected with the respective contents in advance and thus is motivated to explore objects and environment. The motivation to autonomously deal with new topics is thus increased [10].

4. Object modelling: Via AR applications, learners are also able to model objects. These objects may be studied and moved in space and immediately analyzed for the effects of modification in the construction process. Thus, the imagination

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of the learners is promoted, and at the same time their motivation is strengthened [11].

5. Training of skills: AR systems are especially suitable for instruction-based learning in which the learners are directly confronted with the consequences of their actions without putting themselves or the machine at risk. According to [12], applications with collaborative aspects, like in [13], are especially successful in sustainable knowledge transfer.

Based on the explanations given above, it becomes evident that the use of Augmented Reality is suitable both on a technical and a learn-theoretical level to transfer complex knowledge faster and more intuitively.

III. Approach

With the help of the Social Augmented Learning application, the learners get an insight into complex processes and the functioning of printing machines. Relevant content gets aggregated: small assets (e.g. text, graphics, 3D models) are summarized in single slides which are the building blocks of learning modules. Each learning slide consists of a title, a text-based explanation of the depicted content, 3D models of the respective machine elements and, optionally, further 2D illustrations (See Fig. 1). The 3D models can be moved freely in space, animated, complemented by three-dimensional pointer objects, and parts of the model can by highlighted by inking.

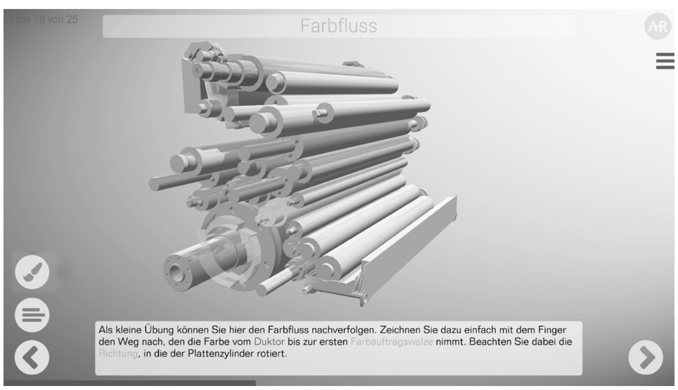

Fig. 1. A slide showing a 3D model of several print cylinders, a pointer object and a textual description.

The content can be explored independently from the real machine using the 3D visualization of the machine components. In Augmented Reality mode, which is commonly used on a tablet, the camera capture of the real machine and the 3D contents overlay one another (See Fig. 2). The printing machine is "opened" at defined sections so that the learner can see the inside through a virtual window. In this course, the virtual machine components have the same position as those inside the real machine. With the help of this visualization, learners can understand complex cause-effect relationships by exploring the 3D model and moving through Augmented Reality, a learning space that is enriched via slowed down animations, additional digital assets, or complementary annotations.

Fig. 2. Using the Augmented Reality mode the learner can see the insides of the machine through a virtual window.

The application has two different modes, which can be used for teaching and learning. In the self-learning mode, learners can autonomously work with the contents, either at home or at the machine. In the presentation mode, an instructor guides a group of learners through the contents. The electronic devices of the learners are connected to the instructor's device via Wi-Fi. He takes control of the application while the group is standing in front of the machine, watching it via the AR mode. He can synchronously skip the slides on all devices, can give further remarks, show and hide additional 2D illustrations, and annotate machine components. Annotation takes place using simple touch gestures on the visualization of the machine. A circular highlight appears in the 3D space (assigned perpendicular to the 3D object) and a three-dimensional line can be drawn onto the machine with a drag gesture. Via these annotations, the instructor can highlight facts (e.g. color gradients or positions of certain machine components) or ask questions (e.g. *"where is the first ink application roller located?").* The annotation function may also be activated for the learners. They can use it for answering questions or to ask questions themselves, such as which function a certain component has.

Fig. 3. Social media connected to the virtual model by tags.

Social media content can be connected to the virtual model or via Augmented Reality to real objects by tags (See Fig. 3). These may refer to blog articles, forum posts, or wiki entries. Instructors and learners are thus enabled to add questions, tasks, and hints related to learning content, as well as to real or virtual objects. The information is located within the 3D space on the machine. Each user can create markers on the machine via drag-and-drop and connect them to content in the social media system. This gives learners the ability to participate in the education and train quickly and easily in a way they are familiar with.

Fig. 4. A WYSIWYG editor is used to create the learning content.

The WYSIWYG editor is a major component of the solution presented in this paper (See Fig. 4). It helps instructors and trainers to easily and intuitively create content for Augmented Reality. This is realized in three steps.

In step 1, the 3D model of the machine is created. The person responsible for this either has to have access to the construction data or has to be experienced in the use of CAD systems to remodel or create the needed 3d model.

In step 2, the virtual windows for Augmented Reality tracking are configured. In our application this is realized by marker posters. This has to be made separately for each machine and each virtual window.

In step 3, the learning contents themselves are created with the help of the WYSIWYG editor. Based on the 3D model and the defined virtual windows, the instructor can create slides with all the necessary information. He can import text and images and can also modify the 3D model by certain actions. Components can be shown or hidden, highlighted with colors, animated, and annotated by labels or 3D pointer objects, such as arrows.

While step 1 is rather complex, steps 2 and 3 can be done easily by persons without any technical affinity. Thus, instructors are able to autonomously create various learning modules on the basis of a single machine model.

IV. Implementation

The application uses the Unity Engine [14] for rendering. Thus, it can be deployed on a great number of platforms, like Windows, Mac/OSX, Android, and HTML 5. Graphical effects, such as shadows or global lighting calculation, are individually adapted depending on the respective computing power.

A. 3D data

The project partner Heidelberger Druckmaschinen AG [15] has provided the CAD data of a printing machine for the implementation of the learning content. As this data consisted of several millions of triangles, the model was reduced to approximately 150k polygons. Two approaches were tested in this course. In the first approach, a complete remodeling was made by hand, taking about 12 working hours. In the second approach, a semi-automatic remeshing was carried out. The model was transferred into a volume representation, cavities inside the model were filled, and the ISO surface was extracted and tessellated. This resulted in a mesh which was then reduced in its complexity via special processing. Subsequently a normal map was calculated for the reduced mesh with the help of the original model. The semi-automated approach brought satisfying results, but still could not reach the quality of remodeling.

B. Tracking

Augmented Reality tracking is carried out on the basis of the Metaio SDK [16] – either marker-based or SLAM-based. SLAM tracking works on the basis of features and does not require visible markers. Nevertheless, it has got a decisive drawback: it has to be configured separately for each printing machine. Due to the fact that there exists a great number of printing machines from different producers, which have to be configured and assembled individually for each customer, marker-based tracking is commonly applied in the Social Augmented Learning project. As to sustainable implementation in vocational schools and training enterprises, the attachment of special marker posters is significantly easier than the complex configuration of SLAM tracking on the basis of local circumstances. Furthermore, the marker posters do not require any special materials and thus can normally be produced on-site.

C. Networking

All clients have access to one common server, which controls the storage, versioning, and distribution of the content. Clients can be used without any connection to the server, though. Any modifications of the learning content is saved locally and synchronized during the following network access. Additionally, the server does the matchmaking of the clients during the use of the presentation mode, as well as the conversion of the 3D models during the import of a new machine into the WYSIWYG editor. The server application is compact and can be used without any installation. This enables the educational institutions to set up and operate a local server by themselves, e.g. within the local network. This is of vital importance as, in some cases, normal internet connectivity in the printing hall does not exist.

D. Social collaboration

The social media content is stored in a Drupal CMS [17]. We use the existing *Mediencommunity 2.0* [18], an established knowledge community for printing and media technology in Germany. Generally, the use of any Drupal system, version 7.0 or higher, is possible. The implementation is based on special plug-ins, which allows the creation and request of the contents and of users, including their roles via a REST interface.

V. Results and Analysis

In the course of the project, several tests were carried out in vocational schools, training enterprises, and job training centers. In the first wave of user studies, 72 trainees and 13 trainers participated in a questionnaire with 37 different indicator questions. As part of the evaluation, these were summarized in the following indices:

Form of learning: Summary of questions regarding the technical aspects of technology assisted learning.

Learning module: Evaluation of the quality and presentation of the learning content.

Application: Questions specific to the technical aspects of the evaluated prototype, e.g. usability and functionality.

Learning process: Questions regarding the roles of trainee and trainer and potential differences in these roles compared to conventional learning processes.

Teaching and Learning: Overall impression regarding Social Augmented Learning, learning with mobile devices, and the organization of the user study.

The questionnaire was constructed with an even-numbered scale, with items ranging from “1” for “totally agree” or “very good” to “6” for “strongly disagree” or “inadequate.”

TABLE I
Indices, Evaluation of the Trainees [N=72]

Indice	Median	β	P
Form of learning	*1.8*	*.27*	*< .05*
Learning module	*1.9*	*.24*	*< .05*
Application	*2.2*	*.19*	*n.s.*
Learning Process	*2.1*	*-.21*	*n.s.*
Teaching and learning	*1.7*	*.26*	*< .05*

The quantitative tests show that there is a significant acceptance of the solution by the trainees, as well as by the instructors and trainers. The data collected from the students was further analyzed to evaluate the possible influences of single indices on the overall impression, with the result that the indices “Form of learning,” “Teaching and learning,” and “Learning module” are most influential.

Qualitative testing is to be made on the basis of guideline-based interviews. By the end of the project, all quantitative and qualitative results will be summarized in a comparative study (Social Augmented Learning in comparison with conventional training and learning methods).

VI. Conclusions and Further Work

This paper has presented the concept and implementation of a learning application which makes use of mobile devices, 3D visualization, Augmented Reality and communication via social networks to enhance training for the media technologist for print profession.

The preliminary tests show that there is a significant acceptance of the solution by the trainees as well as by the instructors and trainers. By the end of the project all quantitative and qualitative results will be summarized in a comparative study.

In the long run, the application is to be adapted to further scenarios and sectors, such as the support of repair and maintenance work, the guidance of workers in assembly scenarios, or in documentation during production.

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