

Chances and Challenges of Using Assistive Systems in Education

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Abstract

Knowledge transfer in educational establishments has experienced a shift from printed media to digitized assistance. Creating adaptive content for educating individuals efficiently has become a major challenge within the design and development of computer-supported learning systems in schools, universities, and vocational schools. Assistance through augmented reality enables the storage of vast amounts of learning materials and annotation of content. Augmenting educational content adaptively provides a personalized experience, thus fostering the motivation of the individual. We present four dimensions to consider when transferring knowledge through personalized educational assistance using augmented reality. This is complemented by the presentation of four research questions based on the previously identified dimensions and related research. We aim to foster context-aware assistive systems that enhance the learning experience.

1 Introduction and Background

Delivering educational content is undergoing a shift from traditional media to interactive learning platforms (Page, 2014; Parnell and Bartlett, 2012). Recent research has shown, that digital content helps to explore and transfer novel education content more efficiently (Lee, 2012). Such educational assistive systems often utilize Augmented Reality (AR) as a key technology in different teaching domains including schools, universities, or vocational schools to encourage apprentices.

Educational assistance on smart devices has emerged as a ubiquitous technology: implementations of AR can be easily found on smartphones, tablets, or systems providing in-situ projections. Supervisors can communicate their teaching content interactively (Shelton and Hedley, 2002) while increasing the motivation of their students and alleviating differences in cognitive resources (Di Serio et al., 2013) at the same time. Furthermore, the workload required for supervising students is reduced. However, content displayed by an assistive system has to be adjusted regarding the learner's educational state and mental capabilities to achieve an optimal learning experience.

Previous research has invested efforts to evaluate the impact of using assistive systems in education regarding learning efficiency. Lee (Lee, 2012) and Wu et al. (Wu et al., 2013) survey how AR can be used to transfer and display educational content. Their findings show, that besides the usage of the right visualization modality, the adoption of the actual displayed content during an exercise yields an important challenge. Using qualitative methods, Shelton and Hedley (Shelton and Hedley, 2002) show that assistance through AR provides improvements in understanding the relationship between earth and sun in school classes. This concept has been extended to visualize physics simulation (Chae and Ko, 2008). Within a literature research, Yuen et al. surveyed how assistive systems in education may impact the overall learning efficiency. A general higher task engagement from students could be observed by several studies (M. Billinghamurst and Duenser, 2012; Mark Billinghamurst, 2002). However, long-term effects were not observed. By simulating the Michelson interferometer experiment, Furió et al. (Furió et al., 2017) present an interactive table which highlights core components using projections.

With the proliferation of AR into the production environments in companies (Fite-Georgel, 2011), assistive systems leveraging AR have shown positive effects in educational establishments within apprenticeships in companies (Funk, Bächler, et al., 2017). Bannat et al. (Bannat et al., 2008) constructed a system projecting assembly instructions directly into the field of view. Several studies (Funk, Bächler, et al., 2017; Funk, Kosch, Kettner, et al., 2016) revealed, that apprentices benefit from AR during their learning phase. The comparison of tablets, head-mounted displays, and in-situ projections has shown that in-situ projections were a highly efficient modality to integrate AR-driven assistance into apprenticeship and manual assembly courses (Blattgerste et al., 2017; Funk, Kosch, and Schmidt, 2016). In addition, Korn and Dix (Korn and Dix, 2016) discuss how digital assistance can be used to enable playful coached learning and thus increase productivity (Korn, 2012). Parts of these concepts have been transferred to support cognitively impaired people. People with cognitive deficiencies have been successfully supported in manufacturing settings using in-situ technologies (Baechler et al., 2016; Funk, Mayer, et al., 2015). Previous research states, that cognitively impaired persons are able to perform assembly tasks over an extended time-span using in-situ projections. Furthermore, AR provides efficient communication of errors within the assembly for cognitively impaired (Kosch et al., 2016), thus helping to reflect on errors made.

Previous work has addressed how different stakeholders can comprehend novel content in an efficient way. However, related work has scarcely discussed how educational content can be conveyed in a methodical way using AR systems. In our work, we present four dimensions, which have to be considered when designing digital learning assistants transferring methodical knowledge. We complement this by stating research questions, which are interesting for ongoing and future research projects desiring to develop digital learning assistants.

2 Contextual Information Representation

To enable decent and unobtrusive support, a digital assistant must be aware of the users' context. The right representation of information and tasks plays a crucial role to avoid overtaxing or bor-

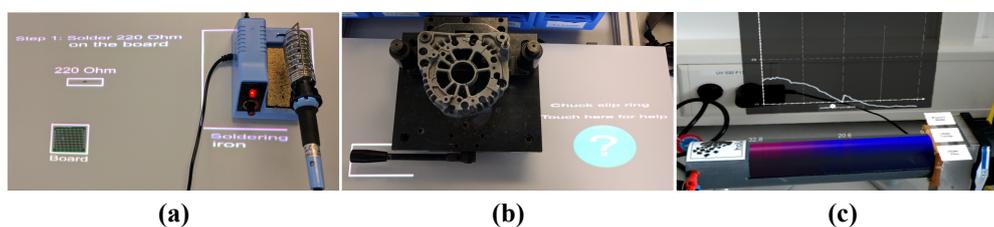


Figure 1: Example scenarios using AR for visualizing educational content. (a): A soldering task with projected in-situ instructions. Objects are highlighted and described to enable a deeper understanding of the actual task. (b): Assembly of an alternator. Help can interactively be requested by touching the projected question mark on the table. (c): Visualizing the heat of metal on a head-mounted display. The chart visualizes the current temperature of the metal bar below and can be dismissed with a hand gesture.

ing the user. From related work, past projects, and semi-structured user interviews, we identify four dimensions which must be considered when presenting augmented content to users.

Content Complexity. We identify the complexity and type of displayed content as an important factor for knowledge communication. The complexity of content must be adapted to the skills of the user. This avoids frustration due to high complexity or boredom when the interpretation of content becomes too easy (Funk, Dingler, et al., 2015). Instead, the appropriate level of content complexity must be decided by the assistive systems 1a. This could be a promotion from the current learning chapter to the next one or ascension counted in levels, where content becomes more difficult with higher levels.

Visual Representation. Unsuitable visualization of content impacts the extraneous mental workload of students negatively (Anderson et al., 2011). Minor changes to the presentation, such as showing pictographs instead of concrete images, can influence the contextual interpretation regarding educational content. Therefore, the visual representation during assistance must conform with the skills of the individual user.

Temporality. Besides of adjusting the complexity and visualization of educational content, feedback has to be provided at correct moments. Displaying feedback while no support is required might lead to an intrusive behavior, while the lack of support might result in frustration. Therefore, educational systems must sense a need for feedback and provide it at the very moment. Combining physiological sensing with contextual actions in assistive systems may provide an answer to the challenge of forecasting the need for feedback (Funk, Dingler, et al., 2015).

Interaction Techniques. Since providing virtual elements is compelling in education, interactive elements incorporated into assistive systems amplify the students' overall learning capacities and curiosity (M. Billinghamurst and Duenser, 2012). Assistive systems can provide help for the current task when a specific button is pressed (see Figure 1b) or a gesture is performed (see Figure 1c). Such simple elements provide control to the user regarding the individuals' learning and comprehension speed.

3 Future Research Challenges

Using assistive systems in education have shown benefits regarding semantic comprehension, collaborative work, and context-aware learning. We envision the proliferation of assistive systems in schools, universities, and training centers as support for content comprehension or practical skill acquisition. Several research questions arise within this domain.

Quantifying Learning Efficiency. A metric to estimate the learning rate and efficiency poses one key challenge. A valid metric for assessing the learning efficiency is necessary to evaluate the learning efficiency, repetition of knowledge, and duration needed to complete a lesson. On a functional level, this can be achieved by measuring the task completion time or asking multiple choice questions after a lesson. However, in order to enable generating design insights, interaction designers must engage in work with the learning sciences in order to build comprehensive metrics that enable informed design choices.

Deployment. Based on the use case, the deployment of a static or mobile digital teaching assistant is a question of high interest. While classrooms benefit from statically deployed assistive systems, apprentices working in motion might prefer head-mounted displays to keep both hands free for interaction with their task.

User Acceptance. Users must tangibly perceive learning benefits and pleasure when using an educational assistive system. Cumbersome usage, context-aware mismatches, or a wrong setting of difficulty can let the user lose control. The readiness to use an educational system depends mainly on previous experience made by the potential user. This calls for extensive user studies and understanding acceptance by engaging in the learning context and working directly in the classroom.

Cognition-Awareness. Quantifying cognitive capabilities contributes to person-dependent adaptation. Contactless sensors, such as cameras tracking facial expressions, can be used to classify emotions (Ekman, 1993). More information can be retrieved using sensors, which have to be placed onto the body. The practicality of using such sensors in real-world scenarios has to be evaluated during the course of future research in this domain.

4 Conclusion

In this work, we presented how personalized teaching assistants have been used to improve the overall comprehension quality in educational facilities. We identified four dimensions for personalized teaching assistance. The impact of these dimensions in practical studies is a challenge for future studies. Based on this, we propose four research questions for future development and evaluation of digital teaching assistants in educational settings. By taking the representational dimensions and research questions into account, we believe that the future development of such assistive agents will provide benefits to employees working in teaching facilities and for learners. We envision these questions as essential components to direct and foster future research in the domain of context-aware assistive environments.

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