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Technical Skills Training Backed by Augmented Reality

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Abstract.

The purpose of our paper is to present experience with the use of augmented reality in professional skills training at a secondary technical school and to discuss its benefits and limits. AR was used in the secondary school study program "Electronics mechanics". Students were trained in building various assemblies backed by AR. They were expected to learn how to input various components into the assembly after the components had been assorted from component catalog. Qualitative research approach was chosen. We collected and analyzed non-numerical data: class observation, interviews with teachers and students. Our intention was to gather in-depth insights into advantages and limits of the AR. As a result of observations and interviews, psychological classification of the impact of AR on student personality at cognitive and motivational level was suggested for further discussion.

Keywords: technical skills, teaching methodology, impact of augmented reality, qualitative research

1 Introduction

Augmented reality can promote interactive experiences with classwork, encourage collaboration between students, improve motivation, and increase learning gains (Dobrovská, Vaněček 2021, A, 2021, B). These benefits rely on effectively implementing augmented reality into the class. When integrated poorly, it faces several limits, including too much focus on virtual information and intrusion of the technology onto actual learning gains. There are other benefits to adding augmented reality to the classroom. There are plenty of ready-made resources that teachers can draw upon to more easily integrate the technology. Several books have already been released that are designed to work with augmented reality, and the only thing that students need to bring to the lessons are their smartphones. Teachers provide the books and students can scan the book pages, bringing them to life on their phones. This means less prep times for teachers. With regard to resources, the availability of resources means that teachers only have to print out enhanced worksheets if they want their students to take the augmented experience home. Pre-made augmented reality sheets can be printed out by the teacher, which makes it easier for teachers to make augmented reality into their preparations (Barak & Ziv, 2013, Akçayir & Akçayir, 2016).

Augmented reality (AR) is a unique instructional medium, affording educators opportunities to create, customize and scale authentic, student-centered, interactive learning experiences (Diegman, 2015). Moreover, AR learning environments allow each student to have a unique path of discovery through real-life symbiosis between technology and learning (Bacca-Accosta, 2014). Augmented reality applications engage students with complex problem solving and educational environments, and many applications successfully apply it to improve both learning and training. It provides new possibilities for different spheres of education, but in these environments it is not yet investigated in its entirety (Akçayir, M.. Akçayir, G., 2016).

Wu et al. (2013) suggested a classification of AR applications within five groups: discovery based learning, object modeling, AR books, skills training and AR gaming.

In discovery based learning, a user is provided with information about a real-world place while simultaneously considering the object of interest. This type of application is often used in museums, in astronomical education, and at historical places (e.g. S. Dali museum, St. Petersburg, 2021). Objects modeling applications allow students to receive immediate visual feedback on how a given item would look in a different setting (Barak, M., & Ziv, S., (2013). In skills training, some applications allow students designing virtual objects, in order to investigate their physical properties or interactions between objects. An immersive, interactive and active learning platform can be formed by applying AR technology into printed books, where despite their many superior qualities, information is provided in a static non-interactive manner. AR books offer students 3D presentations and interactive learning experiences through AR technology. The applications are often realized with head-mounted displays and are augmented with the help of technological devices such as special glasses. Books show that this kind of medium is likely to appeal to digital native learners, which makes them an appropriate educational medium even at the primary level. The technology will not only help teachers in making lessons more interactive but it will also benefit pupils and students by making it easier for them to understand tough subject matters and topics.

Video Games and videos in general have been offering powerful opportunities for educators - they have recognized and often use the power of games in educational environments. AR technology enables the development of games which take place in the real world and are augmented with virtual information. AR Games can give educators powerful new ways to show relationships and connections. Additionally, they provide educators at technically oriented schools with highly interactive and visual forms of learning. Unfortunately, since 2018, misuse of AR or VR crossed the borders of the educational sphere in the concept of deepfake audio and video presentations. The word “deepfake” combines the concept of deep learning with something that is fake. Deepfakes are a form of artificial intelligence — a compilation of doctored images and sounds put together with machine-learning algorithms. Deepfake technology manipulates media by creating people that don’t exist, or by making it appear that real people are saying and doing things they didn’t say or do. The term first became popular in 2017 after a Reddit user called himself “deepfakes” and shared doctored, pornographic videos (Johansen, 2020). He face-swapped celebrity faces onto other people's bodies by manipulating Google's open-source, deep-learning technology (France, 2020). Audio deepfakes became another form of deception (HBO Europe: Without the person´s knowledge, 13.11.2019). Deepfake machine-learning and synthesizing technology created what was known as "voice skins" or "clones" that enabled someone to pose as a prominent figure. An audio deepfake scam was designed to make listeners believe the voice on the other line was someone they knew, and caused listener to take an action (e.g. sending money). As detection technology has advanced, so did the quality of deepfake technology. But there still are ways to spot deepfakes either by user, or with some AI help (Johansen, 2020).

In recent years, there has been an increasing interest in applying Augmented Reality (AR) to create unique educational settings. We may find some excellent examples of augmented reality in education worldwide. Ability to connect reality and digital content has been steadily improving, opening more options for teachers and students. However, there is still a lack of review studies with focus on investigating factors such as: the uses, advantages, limitations, effectiveness, challenges and features of augmented reality in educational settings. Anyway, 14 different benefits of AR in our source literature of which two (Improved Learning Curve and Increased Motivation) account for more than 20% of all benefits mentioned (Diegman, 2015).

2 Methodology

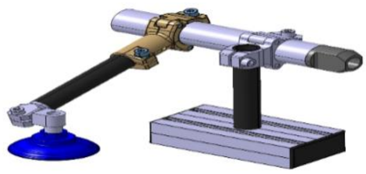
We chose qualitative research approach. We collected and analyzed non-numerical data: class observation, interviews with teachers and students. Our intention was to gather in-depth insights into advantages and limits of augmented reality in basic practical skills of secondary technical school students. Augmented reality was implemented in the laboratory area of a secondary school. Two groups of students participated in the training, (32 students and 2 teachers) in a course *„Technical documentation"* in a study program *„Electronics mechanics"*, in the 3rd year of study program. The course plan covered 4 teaching units, one of them called *"3D modeling of a complex assembly*", with 7 teaching topics, with time allowance of 90 minutes each. There were 4 subtopics in the teaching unit: *Component set creation, Manipulation with glasses, Complex sets creation and Construction of suction cup frame*. Students were trained in groups of 10-12 participants. After training experience, the learner was expected to be able to input various components into the assembly after the components had been assorted from component catalog.

3 Research Description

In the introductory phase of training, students were prepared how to create components sets: they were informed how to work with the catalog of components, how to assort them, how to choose the proper components and how to put them into the set (mechanical skills training).

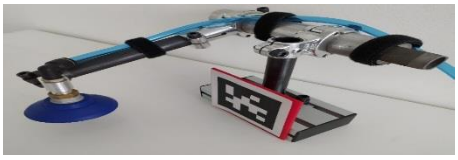
Then they learnt how to manipulate with glasses (deployment, function control), installation of data, model completion according to the displayed data and real model control.

Picture 1: Student training task 1



In the second phase of training, students gradually learnt how to display basic geometrical entities, to understand principles of quotation of geometrical shapes, creation of 3D components by protrusion or rotation, input standardized components from catalog, and prepare future model of complex machine parts. This phase of training was based on spatial and surface perception training.

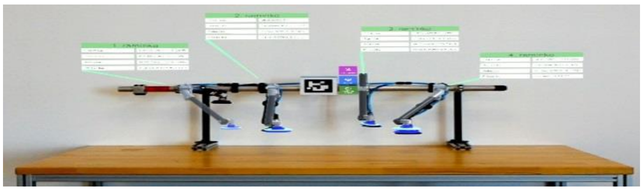
Picture 2: Student training task 2



After students had been taught how to model components of the assembly, they were subsequently asked to complete the assembly in their individual work in class. They were expected to work with database of components, choose the right components, define positions of components, define mutual distance and angles of components, reflect completion of assembly and test the quality of assembly by deconstruction and reconstruction. Role of the class teacher was dominantly encouraging in this phase of training: stimulating and/or gently correcting students in their individual work, backing their suggestions and ideas, explaining pros and cons. In this phase, higher cognitive abilities were required in their interconnection from the students.

In the last training phase students were supposed to construct *the suction cupframe*: select data for the model, set them into running, specify their reference point, complete model with the 3D glasses support and control final model. This competence was considered to be the final training objective.

Picture 3: Student training task 3



4 Results and discussion

Observation in class

We conducted observation in class during all training phases (introductory training phase, intermediate training phase and advanced training phase). During initial phase students were getting basic knowledge on work with catalog and electronic devices. Teacher attracted attention of students from the very beginning and obviously increased engagement level, (although some students were more active than other). Augmented reality brought to life abstract topic such as set theory and logical reasoning but it focused on training practical skills. Students were practicing with help of experiential learning by trying several iterations to find out the best and the most suitable combinations. Unlike other technologies (e.g. a video solution minimizes the involvement of teachers in the classroom, rather it lets teacher guide the whole session), AR let teachers act as a guide during the whole session, take charge of the classroom by mentoring the session. They were explaining, asking and answering questions, encouraging, made students familiar with the technology, did not just give orders and instructions. They were someone who students can count on for support and not someone they fear conversing with. Becoming mentors, teachers changed the class climate to become fun and interactive, without losing their authority. More teacher-student collaboration was observed.

Interviews with teachers

We held interviews with 2 teachers who performed the training based on use of AR. Our first topic of discussion was the cost of AR equipment – buying all components still seems to be too high (total cost exceeded 6 000 dollars in 2017, with extra charges for specialized software, computer equipment and components for student training). For most schools, the cost is still too high unless they gained funding from government, industry or international resources.

Second topic focused on discussion with teachers about their opinion on benefits and limits using AR in technical training. These were their remarks:… humor moments occur during training…. new technology brings a strong motivational effect…. students are pulled in work, …they got excited about it and motivated as many had enjoyed experience with AR and VR gaming. They were prepared to collaborate… they were giving advice to each other. However, teachers mentioned some limits ….”students must be divided into small groups for a good training, 10-12 students are maximum, and it would be more convenient for an educator if the group were even smaller”…. “a good preparatory work of teacher is a condition for successful management of training in class, especially in the first introductory phase when students are introduced into the AR use”.

Another teacher remark touched the emotional aspects of using AR: unexperienced students need encouragement from teachers (some of them lack previous experience with other AR facilities but gaming). Once students lose their uncertainty about work with new technology more spontaneity and activity are observed. Teacher should encourage those students who remain passive. As to cognitive qualities, students seem to remember facts better and their readiness to complete the task seems higher than in “normal” classes.

Interviews with students

We held interviews with a group of 32 students at a secondary technical school in a study program *„Electronics mechanics“.* The majority of students (28 of 32) perceived themselves as beginners or intermediate in the AR world and indicated that they perceived a high interest in AR content, but in the form of excitement and enjoyment. Their preferences included the apps they had been using for several years, but they had not been able to move beyond traditional enjoyment practices.

They were asked to express their views of training with AR including its advantages and limitations. Below see their most frequent remarks:

Positives: “something new for real practice…, enjoyable…, having fun…, training with immediate results and corrections…, makes them go on with training for a longer time unless they managed the task…., feeling like learning and playing at the same time…., wanted to be as good as others…, I would practice even more…, much better than in traditional workroom.., I could show my skills…” Negatives: “it made me annoyed as we had to share the equipment with other guys…, it made me tired, I could not go on for several hours…, I lost my concentration after a while”…, we had sometimes problems with setting and it took time to solve them…”.

As a result of our observations and interviews, we tried to assort and summarize our findings and suggest a psychological classification of the impact of AR on the student personality for further discussion, with special attention to possible educational effects:

Positive aspects of training backed by AR – the pedagogical and psychological potential of AR apps:

- **Cognition:**
- supporting deeper understanding *(„aha“ moment*)
- improving conceptualizing complex (abstract) information
  - deeper understanding level
  - increased concentration
  - better information retrieval
  - **Emotions and motivation:**
  - highly motivating for students
  - reducing learning stress (*imposter syndrome*) if backed by teacher´s help
  - enjoying moments of humor when funny errors occured
  - **Personality development**
  - encouraging student collaboration
  - building healthy assertiveness (asking for help)
  - improving individual persistence level when completing the task
  - **Other**
  - AR usable for different courses and different school programs

Negative aspects of training backed by AR

- cost of equipment
- suitable for small groups of students only
- limits in mutual communication of apps
- existing data in the system cannot be easily actualized
- longer work with 3D glasses can be unpleasant for users
- computer performance should be faster and smoother if to be closer to reality

5 Conclusions

We shared our experience on use of AR in technical skills training at secondary technical school. Qualitative survey was conducted on a small sample of teachers and students with an emphasis on discussion. Our research decision aimed at understanding teacher and student opinions on effective use of AR in education. We agree with other findings each AR application is in its own way unique and therefore the identified benefits may not apply in each context. Each application has to be implemented thoroughly to prevent drawbacks in user interaction or system failures in order to profit from benefits. Special user groups – in our research students of secondary technical school - can benefit in different, as well as additional ways due to their requirements to learning methods and the characteristics of AR. Results of our research cannot be generalized, but we believe AR is eligible to be used in different educational environments, and many applications successfully apply it to improve learning. Our findings indicate that specific directions of AR applications are more likely to lead to certain benefits such as increased motivation. Future research is needed to investigate the causality between benefits and challenges in detail.

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