Implementation of Augmented Reality into Student Practical Skills Training

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Abstract. Augmented reality is eligible to be used in educational environments, and many applications successfully apply it to improve learning. It provides new possibilities for different spheres of education, but in these environments it is not yet investigated in its entirety. This paper's objective is to present experience with utilization of augmented reality in professional skills training at a secondary technical school and to discuss its advantages and limits.

Keywords: Augmented reality · Technical subjects · Teaching and training

1 Introduction

AR is one of the most emerging technologies in education these days. AR applications can be used in many different platforms such as desktops, notebooks and mobile devices. In the recent years, augmented reality has been given different meanings. Reference [3] defines AR based on the reality-virtuality continuum as augmenting natural feedback to the operator with simulated cues. The reality-virtuality continuum allows distinguishing between the concept of AR and concepts such as Virtual Environments (also known as Virtual Reality (VR)) and Augmented Virtuality (AV)). While VR deals with settings where the participant observer is totally immersed in a completely synthetic world, AV is concerned with environments in which "the primary world being experienced is in fact [2] predominantly 'virtual'" [4] and augmented with information from the real world. Additionally, reference [1] mentions a more restricted definition where AR is seen as form of virtual reality where the participant's head-mounted display is transparent, allowing a clear view of the real world.

AR is eligible to be used in educational environments, and many applications successfully apply it to improve learning. It provides new possibilities for different spheres of education, but in these environments it is not yet investigated in its entirety. Researchers and educators face different directions of AR applications, which may differ regarding their potential benefits.

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Some references suggest a classification of AR applications within five groups [6, 7]:

- **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.
  (In our view, teachers should include principle of discovery-based learning into everyday class practice as psychology of learning has brought evidence of improved cognition quality).
- **Objects Modeling**
  Augmented reality can also be used in objects modeling applications. Such applications allow students to receive immediate visual feedback on how a given item would look in a different setting. Some applications also allow students to design virtual objects in order to investigate their physical properties or interactions between objects. (This type of application can be also used in most technical educational programs).
- **AR Books**
  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 and non-interactive manner.
  AR books are books which 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. The first implementations of AR Books show that this kind of medium is likely to appeal to digital native learners, which makes it an appropriate educational medium even at the primary level.
- **Skills Training**
  Support of training individuals in specific tasks, especially in mechanical skills training, is described in this category. Such applications are, for instance, used in airplane maintenance, where each step of a repair is displayed, necessary tools are identified, and textual instructions are included. The applications are often realized with head-mounted displays.
- **AR Gaming**
  Video Games offer powerful new 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.

  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 [3].

2 Use of AR in Teaching Technical Subjects at a Secondary Technical School

We would like to discuss experience with utilization of AR in teaching a course *"Technical documentation"* at a secondary technical school in a study program *"Electronics mechanics"*. The course is implemented into the 3rd year of study program, the course plan covers 4 teaching units, one of them called *"3D modeling of a complex assembly*", with 7 teaching topics, with time allowance of 90 min each. There are 4 subtopics in the teaching unit: *Component set creation, Manipulation with glasses, Complex sets creation and Construction of suction cup frame*. Students are trained in groups of 10–12 participants. After the training experience, the learner is expected to be able to input various components into the assembly after the components had been assorted from component catalog.

In the introductory phase of training, students are prepared how to create components sets: they are 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. Then they learn how to manipulate with glasses (deployment, function control), installation of data, model completion according to the displayed data and real model control (Fig. 1).

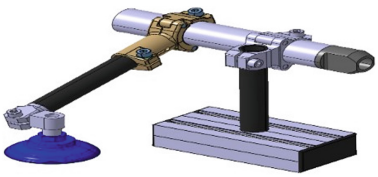

Fig. 1. Student training task [5]

In the second phase of training, students gradually learn 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 (Fig. 2).

After students had been taught how to model components of the assembly they are subsequently asked to complete the assembly in their individual work in class. They are expected to work with database of components, choose the right components, define

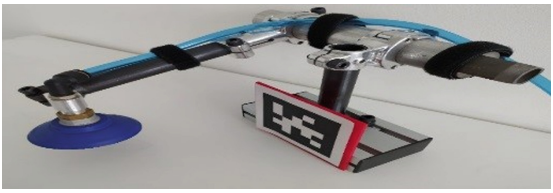

Fig. 2. Example of a student work I [5]

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 is dominantly encouraging in this phase of training: he should stimulate and/or gently correct students in their individual work and back their suggestions and ideas.

In the last training phase students are supposed to construct *the suction cup frame*: select data for the model, set them into running, specify their reference point, complete model with the 3d glasses support and control final model (Fig. 3).

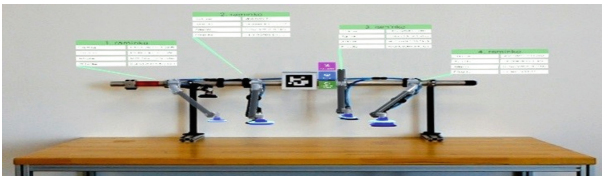

Fig. 3. Final model – a suction cup frame

3 Discussion

We held interviews with teachers who had prepared training course supported by AR at a secondary school, we discussed their experiences and tried to systemize their opinions how to improve teaching with AR.

Our first topic in discussion was the cost of AR equipment – buying all components still seems to be too expensive and few schools are able to invest into complete AR equipment (the cost of quality 3d glasses suitable for training was 6000 dollars in 2017, plus specialized software, computer equipment and components for student training cost additional several thousand dollars). For most schools, the cost is too high unless they apply for funding from government, industry or international resources.

Other point of discussion with teachers was their opinion on benefits and limits using AR in training. These were their remarks: humor moments occur during training…. new technology brings a strong motivational effect…. students are pulled in work, they get excited about it and motivated as many had enjoyed experience with AR and VR gaming. They are prepared to collaborate… they give advice to each other.

However, there are some limits, too:…students must be divided into small groups, 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 phase when students are introduced into the AR use.

Once students lose their uncertainty about work with new technology more spontaneity and activity is 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.

As a result of the interview, we suggest a classification of the impact of AR on learning for further discussion, with special attention to possible educational and psychological effects on students:

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

- **Cognition**
  - supporting deeper understanding *("aha" moment*)
  - improving conceptualizing complex (abstract) information
  - deeper understanding level
- **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 occur
- **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

4 Conclusions

AR is eligible to be used in educational environments, and many applications successfully apply it to improve learning. But it should not be considered a magic bullet in educational environments. 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 can benefit in different as well as additional ways due to their requirements to learning methods and the characteristics of AR.

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