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# Towards VR-based systems for school experiments

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**Abstract**

In this paper we present the steps towards a well-designed concept of a VR system for school experiments in scientific domains like physics, biology and chemistry. The steps include the analysis of system requirements in general, the analysis of school experiments and the analysis of input and output devices demands. Based on the results of these steps we show a taxonomy of school experiments and provide a comparison between several currently available devices which can be used for building such a system. We also compare the advantages and shortcomings of VR and AR systems in general to show why, in our opinion, VR systems are better suited for school-use.



*Keywords*: VR-based systems; Edutainment; School experiments; Interaction devices;

## 1. Introduction

Appropriately teaching children knowledge about our world, the universe and complex processes of life is a challenging task, because many scientific processes and their correlations span multiple layers, some of them impossible to perceive with basic human senses. In order to visualize these processes, some kind of approximated models and descriptions are used. On top of that an observer should possess the ability of abstract thinking in order to understand this transferred knowledge. The necessity of being able to think this way is usually just what makes it difficult for children to master science. At this point the utilization of novel

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technologies like AR or VR could be helpful. Nowadays, AR and VR-systems are important because of their potential to make work easier, complex things better understandable and engineering and experimentation costs lower. They have already found their place in many different domains like medicine, automotive industry, mechanical engineering and pilot training. Usage of these technologies at schools can change the learning process in a positive way because they will make it possible for teachers to visualize the theoretical models more clearly and also allow students/pupils to experiment with these models in different ways, thereby making them more understandable. They may have a positive impact on education quality [1-4].

However, the design of AR and VR-based systems for school experiments is still a big challenge because of factors such as cost, usability, robustness, healthiness and maintainability. All these factors must be considered not only during the device selection phase but also during the implementation of interaction techniques and the whole software system. It is also important that the system supports a wide range of experiments from different scientific areas to make it worth the investment.

In this work we concentrate on the design process of a system for the accomplishment of virtual, scientific school experiments. We analyze school characteristics and demands to define the system requirements and then propose a configuration for a system, which might be attractive for education institutes.

The paper is structured as follows: Section 2 contains information about related work. In section 3 a taxonomy of school experiments is presented from the developer's point of view. In section 4 the steps are proposed that need to be done during the system design. It also includes the analysis of the current state and consequential requirements the system must fulfill. In section 5 the example implementation of the system is presented. Finally, section 6 summarizes the main statements made in this paper.

## 2. Related work

During the last decade numerous efforts were made to put VR/AR systems into a school context for educational purposes. In this section we provide a brief overview of some of these projects.

The "Cyber-Classroom" [5] is a commercial product that was developed by the Company VISENSO. It is an interactive system focused on school application, making use of current VR technologies. Starting at several thousand Euro, the main disadvantage of this system is its price. Also, the system is only aimed for group use and cannot be used as a single place system.

Another project is "Science Center To Go" [6] which was started in 2010 in the context of the "Lifelong Learning" program. In the scope of the project a set of miniature exhibits was developed. Each exhibit represents some kind of virtual experiment from a particular scientific area. AR technologies were utilized in the project for visualization and interaction purposes. The developed exhibits are marker-based, but the markers used are similar to the real objects they represent. The system's main disadvantage is the small set of experiments it offers. Also, the object based markers result in high management and maintenance overhead. Extending the exhibits set increases the number of objects, therefore also increasing the overhead further on.

In the project "Mathematics and geometry education with collaborative augmented reality" [7] an interactive AR system for learning the concepts of mathematics and geometry was realized. The software offers numerous functions for construction and manipulation of geometric primitives. In total three hardware configurations are supported: The Augmented reality classroom, Projection Screen Classroom and Distributed Hybrid Classroom. The project provides a good platform for further work, but due to utilization of expensive input and output devices it is not really applicable in schools.

Surely there are a number of other projects with the same aim. The mentioned projects however present the three common directions developers usually take during the design of interactive systems for schools: pure VR, pure AR and mixed. They also show that the implementation of such a system is theoretically and practically possible. However, the main problem still is the price. Trying to get around that problem and make the system more affordable for schools, the developer designs it in such way that it can be used by many students