Virtual Science Lab

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Figure Rebuild of a real laboratory (bottom) in a Virtual Reality laboratory (top: Standing in the real laboratory and putting on the VR glasses means standing in a virtual copy of this room on the same starting point.

*Abstract* **— The Virtual Science Lab is presented below. It is a virtual reality application that is intended to intuitively illustrate and explain experiments from various branches of science to the user. Unity was chosen as the development environment. The application was optimized for the HTC Vive Pro. Experiments from various fields of science (e.g. mathematics, chemistry, computer science) are presented for a user to carry out. There is an assumption that through playful and native testing, the user is willing to learn about science indirectly. A look into the future shows that this assumption must be evaluated in tests and that a control system must be evaluated for a wide variety of hardware variants.**

Index Terms: *Virtual Reality; Digital Learning*

# Introduction

Laboratories and exercises are an integral part of education in all science and engineering programs at universities all over the world. Simulation and training was and is still one of the major application areas of virtual reality. So it is only natural to think about virtual application for the preparation and post-processing of laboratories and exercises in bachelor and master programs at universities.

The idea of using 3D graphics and interactive applications is not new. Examples of such (desktop) applications can be found beginning with the nineties, e.g. in [5]. Recent examples for the usage of VR in K12 or universities can be found in e.g. [1], [2] or [4].

In the future virtual and augmented reality applications will be a part of distance learning and open universities. With virtual reality the tasks in a laboratory exercise can be carried out as natively as needed and possible. E.g. by moving the hand und touching the button of a virtual machine like using the machine in reality. Using a room-scale setting the participants can move in the lab like in reality. This natural interface to the lab makes it easy for a virtual solution, the barrier of entering the virtual lab should be much lower than using a desktop application with mouse, keyboard or touch interface.

# Related Work

Distance learning and open universities are more and more coming towards common practice. STEM departments use computer based learning for decades. *Open MINT Labs* [3] is an example for virtual, desktop- and browser-based applications for the preparation of students, virtual experiments and of the post-processing of the students in a learning management system like OpenOLAT [7]. *PraxiLabs* [6] is a similar project like ours on giving science a digital environment. Apps or software on desktop or mobile devices are basic concepts our work is based on. *PraxiLabs* is built as a 3D computer game like software the user has to control via touchscreen, controller or mouse and keyboard. These controls are less natural as virtual or augmented reality where our project is based on. *OpenMINTLabs* sets their goals similar to our project - adding virtual parts to real laboratory experiments. But the applications in OpenMINTLabs are browser-based and targeted to desktop or mobile devices.

# Virtual Science Lab

Virtual Science Lab is part of the Open-Source project XTRA-Labs at our university. The goal of the project is to enhance laboratories and exercises at our university with augmented and virtual reality simulations as a part of the learning management system. Experiments and tasks can be used in preparing for the real lab. Experiments can be done without risk of harm, e.g. in chemistry of physics labs. Students can do the experiments anytime, anywhere and how often they want or need to. In addition, no valuable resources are wasted, such as chemicals or laboratory equipment. In the school and university context, the Virtual Science Lab can be an immense relief for teachers and learners. There is an assumption that through the playful and safe handling of laboratory equipment, a greater knowledge in the respective area accumulates with the handling.

The current status includes experiments from the fields of chemistry, physics, mathematics, electrical engineering, biology and computer science. These include an experiment in which substances can be safely held in an open Bunsen burner flame and the flame then changes color, various sorting algorithms, electronic circuits with measuring devices or examinations of substances with a microscope. There are hardly any other branches of science and opportunities for experimentation, and it can always be expanded as needed.

Every experiment has information like conclusion, given task and theory behind it included as different kinds of objects. Sometimes you got a clipboard with a letter, posters on the wall or a beamer projection. These different ways to get your information keeps the user motivated to research and interact with more and more experiments or objects. Figure 2 shows such an example with a training for bubble sort for computer science students.

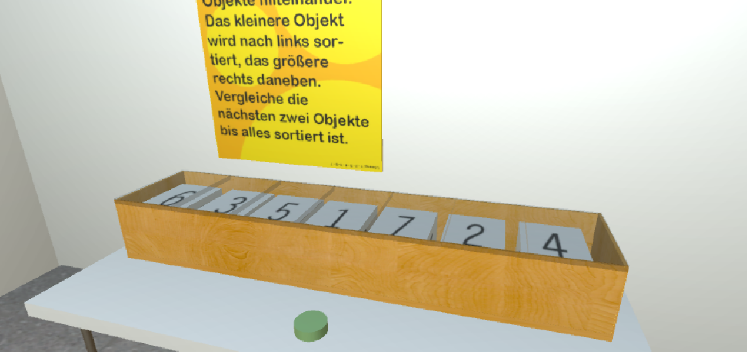


Figure One example of a task for a computer science exercise:. Bubble sort – a simple sorting algorithm – including an information poster on the wall behind. On the virtual poster a description of the task and the conclusion can be found. Users can read it at any time during the simulation.

# Discussion

The future steps primarily include a mobile version that will initially work with Android and iOS devices with virtual, but also with augmented reality. A mobile version using low-level hardware gives students the opportunity to train for the lab at home. It is planned to install a virtual lab located in the neighborhood of the real laboratory to create a learning facility just in front of the real tasks. The advantage of this would be that it is possible for a larger group of people (e.g. lecture room with many students) to have the same experiment carried out at the same time.

The big problem with these applications is to include different devices with different control types and to look at different hardware. In addition, a kind of empirical field test makes sense by testing whether students who complete the Virtual Science Lab could do better in a suitable test than a group that the laboratory has not seen.

The construction of the laboratory rooms more and more resembled a process in which the same steps were carried out one after the other. First the room is delimited by walls, floor and ceiling, a door is added in front of which the camera is placed so that one enters the room at the position of the door. Then, if necessary, tables are arranged, as are the various equipment parts necessary for the intended experiments. Finally, the functionality is added in form of software which are written to enable the experiment to be carried out. The exercise is then tested in the virtual reality laboratory and, if necessary, bugs are noted and fixed. This evaluation process is carried out iteratively any number of times until the result is satisfying. In this way, any number of laboratory rooms can be supplemented in the following, thus covering a wide range of specialist areas with different experiments that have not yet been included (e.g. geography). In this way the creation of more and more application can be based on reusable workflows and software.

As we are working in an open-source setting the results will be available in public Git repo – not only software, but all assets and documents.

# Conclusion

This project shows that the Virtual Science Lab can offer an opportunity to improve school and university teaching. Many scientific experiments are already safe and playable and marked with explanations and instructions.

A look into the future shows which changes need to be addressed and how to continue with the laboratory. On the one hand, a version of the application is required that can be executed and controlled on any hardware. The focus should be on cheap alternatives for mobile devices, so that a larger group of pupils or students can work on experiments at the same time.

In addition, evaluations must be carried out to determine how far a student's knowledge is gained by completing the tests in virtual reality.

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