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WORK IN PROGRESS: A Study on Student Feedback Regarding the Usability of Online Laboratories

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Work-in-Progress: A Study on Students Feedback regarding the Usability of Online Laboratories

Abstract

Online Laboratories allow students to perform virtual and real experiments remotely. The user interfaces of the laboratories are delivered by Web-based client applications that can be accessed with every modern browser. This work presents the results of a survey carried out in the scope of a national project that aims among others to gain knowledge from peer-feedback to improve usability and to increase workload of Educational Online Laboratories, as well as to explore age-dependent requirements for the integration of Online Laboratories in classes of secondary schools.

In our project we work together with three secondary schools from Austria and some others from European countries with a focus on STEM subjects. Each Austrian project partner develops its own Educational Online Laboratory in an area that suits their curricula. To assure that the laboratory experiments are qualified in terms of their pedagogical goals (usability and age appropriateness for use in classes), a part of the project is to ensure that every laboratory goes through a pilot phase, where it is tested by students of the same age from participating schools.

During the project, the Austrian Federal Ministry of Science, Research and Economy invited us to take part in a contest with the goal to involve young students in science topics. We have participated in this contest, since one of our project goals is to gain insight from students and teachers from secondary schools concerning the potential usage of Online Laboratories in class. Our task for the students was to try out Online Laboratories and to provide feedback regarding usability, experienced challenges and personal impressions. The contest allowed us to test the stability of our Online Laboratories in a large scale, before they were presented to our international school partners. The evaluation of the feedback from this contest helps us to understand problems and design flaws, but also to detect what aspects keep the students interested. This paper will provide a statistical analysis of those aspects.

Introduction

Online Laboratories provide access to experiments over the Internet. Remote laboratories, as a subset of them, even provide access to experimentation equipment, i.e. real hardware. To control this hardware, lab developers program clients, which are usually working within a Web browser, or at least are downloaded from it. Thus, Online Laboratories offer new possibilities for teachers all over the world. The experiments and its hardware can be accessed on a 24/7-basis and the users do not need to own any equipment apart from a computer, smartphone or tablet with Internet access. Therefore, Online Laboratories provide a simple way for teachers to enhance lessons with "hands-on" practice without actually buying, installing and setting up hardware[1].

In the scope of our project, we are collaborating with three of our local higher colleges oriented on technology and crafts (Austrian acronym: HTL). Students of these schools are usually between 14 to 19 years old. Each school has its own team of students and teachers. Their main task is to conceptualize and develop a remote laboratory, which can be included into their curricula. Due to high expertise of our department, with many years of experience in the field of remote engineering, our focus is to guide the schools in the development process; i.e. to provide know-how, software and equipment to build the lab. Apart from that, our research goals of the project are stated as follows:

I. Development of adaptive interfaces for a global integration and re-usability of online laboratory software and hardware[2].
II. Studies on age-appropriate requirements for the integration of online laboratories in teaching and development of general guidelines.
III. Gaining knowledge from peer feedback to improve the user experience (usability) and increase the utilization of online laboratories.

To fulfill our third goal, we plan to hold a pilot phase, which is scheduled from April to May 2016. In this phase, all remote labs will be presented to international partners – secondary schools from Romania and Slovenia. Apart from this, the Austrian Federal Ministry of Science, Research and Economy held a month-long contest in October 2015 to involve students into science projects. Applicants were between 10 to 18 years old and it was hoped to boost their interest in STEM subjects. We found this to be a great opportunity to promote remote labs to a wider audience and to get first impressions of how students use them. Thus, we took part in the contest with already existing remote labs and provided a survey for the students to fill out for each lab they tested. The idea is that the results and findings can benefit the development of the remote labs from this project already before the pilot phase starts.

The next chapter explains the remote laboratories and their clients used in the contest. The third chapter contains the survey questions, user statistics and results. The last chapter discusses the results and gives an outlook how the project is continued.

The Labs

All labs allow to control real hardware, are browser-based and use the iLab Shared Architecture of the MIT[3] for authentication and as a communication interface. Some of the labs provide recorded or streamed video of the executed experiment. The following Online Labs were available for testing during the contest.

Chebyshev Filter Lab:

The Chebyshev Filter is part of a bigger set of experiments in the field of electronics. At the time of the contest it was the only experiment from our project which was available since the others were still in development. The lab provides a function generator where the waveform type and its voltage and frequency can be set by the user. Students of electronics can learn how the parameters influence the frequency response of the filter.

Radioactivity Lab:
This lab was developed and maintained by The University of Queensland, Australia. It has radioactive sources, like Strontium-90, various absorbers (from paper to lead sheets) and a Geiger counter. The user can select the radioactive source, the absorber, measurement time and the distance between Geiger counter and radioactive source.

Blackbody Radiation Lab:
With this lab students can measure the radiated power of different light sources. Besides a variety of light sources also three sensors which measure the light in different wavelengths and distances from the light source are available for selection.

ELVIS OP-Amp Lab:
The ELVIS laboratory is named after the modular NI ELVIS platform (Educational Laboratory Virtual Instrumentation Suite)[4] by which this laboratory has been set up. Various fixed electronic circuits can be measured with this platform. At the time of the contest two operational amplifier circuits were installed.

VISIR:
VISIR stands for Virtual Instrument Systems In Reality. On a VISIR breadboard all circuit components are interconnected and the connection to real instruments (laboratory power supplies, frequency generator, digital multimeter and oscilloscope) is done by using relays. The lab owners can insert various electronic components on the printed circuit board, which are then available for students to assemble on the GUI. Built-in safety mechanisms make short circuits impossible.

Survey – Questions and Answers

To carry out the survey we used Google Forms. Over the course of one month multiple classes from ten schools participated in the tests. All labs together had more than 700 valid entries. Since the survey was focused on students from age 10 to 18 we tried to keep it short and simple. Thus, the survey should not require more than 5-10 min to complete. The distribution of feedbacks is shown in fig. 1.

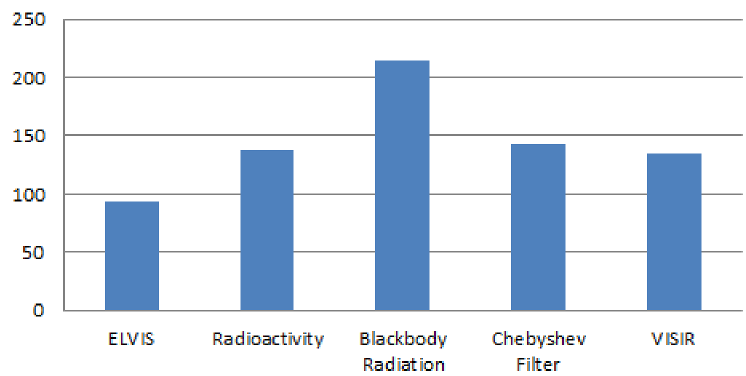

Fig. 1: Number of feedbacks per lab

The first part of the survey required personal information of the student or teacher, like name, age and school. The purpose was to avoid double or fake entries. In respect of the participant's privacy none of this information was shared with others. Second, we asked for the lab the students tested. Thus, testing multiple labs required the student to fill out multiple feedback forms. The main part of the survey was oriented on the user's experience. We split the questions into:

1) Grid type questions, where the students could select whether they agree or not to a statement about the lab (see fig. 2) and
2) Paragraph type questions, where students could write open-ended answers. Students were asked about their interest in Online Laboratories, what they found challenging and what they thought could be improved.

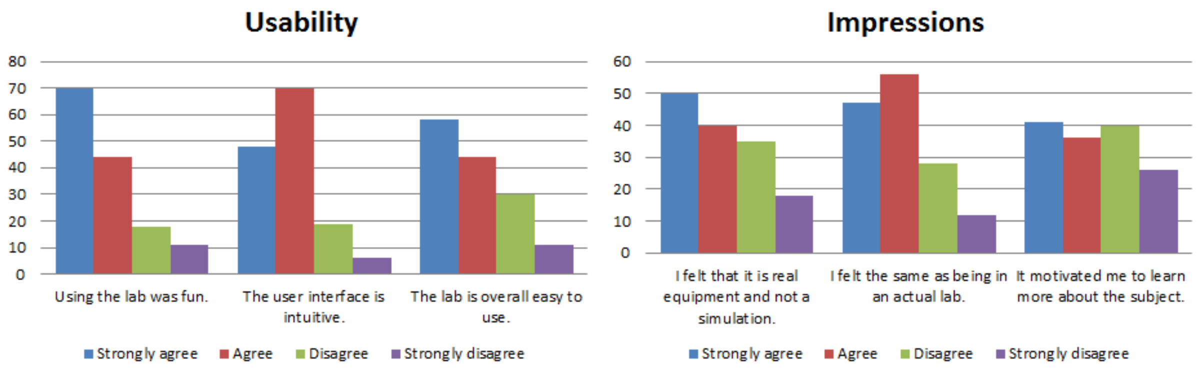

Fig. 2: Usability and Impressions of the Chebyshev Filter Lab (translated from German)

With the statistics of each lab, as seen in fig. 2, we could determine if the GUI of the lab client felt intuitive or if the level of acceptance of an Online Lab experience can compete with hands-on labs. With the paragraph type questions students were able to describe their thoughts more thoroughly. Answers were summarized, shortened and put in one of the following three categories:

1) Challenges in using the lab (from a student's perspective)
2) What students liked
3) What could be improved

Here are the answers of the Radioactivity Lab:

Category	**Answers**
Challenges	No expert available to ask questions Long execution/waiting time Complex handling Replacement of real experience
Like	No danger from radioactivity Live webcam Clear instructions on what to do
Improve	Other languages (Lab was not available in German) Improve waiting time Comparison of measurement values Instructions in HTML instead of PDF

Table 1: Answers of the Radioactivity Lab filtered and shortened

Answers from the other labs were similar. However, the complex handling of the Radioactivity Lab was especially criticized. Generally speaking three main issues can be addressed:

1) The provided instructions focused on the lab handling. Some teachers didn't spend enough time to prepare for the topic (i.e. to explain the concept or physical phenomena). Thus, some students had problems in interpreting the results.
2) If a whole classroom executed experiments, the waiting time for experiment execution became too long for some students.
3) PCs in classrooms have often very restricted access for students. Even a simple task like opening a PDF file can lead to problems. The VISIR Lab was very often criticized by students for using Adobe Flash.

Discussion and Outlook

Both types of questions, grid type and paragraph type, were equally relevant. The grid type questions have given us a statistical overview, while the paragraph type questions allowed the students to point out flaws in design and usability and let them explain their concerns. On the Radioactivity Lab for example, the statistic has shown us, that students don't find the GUI very intuitive. However, the descriptive answers allowed them to point out how they struggled with the interface. With these answers in mind a new Web client is now in development.

Some students complained that teachers couldn't help them enough on the topic of the lab. This might be a result of a lack of learning material from our side. For the pilot phase in the future we plan to embed the inquiry learning space framework from the European project Go-Lab, which aims encourage young people aged from 10 to 18 to engage in science topics, acquire scientific inquiry skills, and experience the culture of doing science by undertaking active guided experimentation[5].

The often criticized long waiting time is not caused by the Internet speed, but due to many accesses at the same time. Some labs, like the Radioactivity Lab or the Blackbody Radiation Lab, have mechanical parts which are moving. There are various solutions to cope this problem:

1) Improve the speed of the mechanical parts
2) Build multiple labs with the same hardware to execute more experiments at a time
3) Compare the parameters the students have set and bundle the experiments to one
4) Look up the database for already executed experiments and just send the results

The first 2 methods are sometimes not affordable for lab developers – and also not reasonable if the lab is 95% of the day on stand-by. Method 3 is difficult to implement, since not all experiments are executed at the same time. Further, it is similar to method 4, which we already have implemented in our software. However, this method only works with recorded video, not with video streams. Additionally, since measurements always deliver different results, even if the same parameters are set, it should be discussed if this method is not counterproductive to the principle of using Online Laboratories with real hardware.

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