Abstract

Due to the Bologna process and its internationalization of European degree programs to ensure comparability in the standards and quality of higher education qualifications, universities in Germany are now dealing with two important issues. On one hand, with the introduction of the bachelor degree, basic subjects had to be reduced in terms of workload to shorten the study duration to the length of the bachelor program. On the other hand, German universities are now encountering the problem that more students are registering for these new bachelor degrees, which thus is now requiring a reduction of lab classes due to organizational limits in the university. Therefore universities have had to remove 1 to 2 lab classes per semester for most majors. This means that there is a reduction of 16%-50% per semester, since 4-6 labs were generally offered per semester. Since one of the prime qualities of the German universities of applied sciences („Fachhochschulen“) is their practical-oriented teaching in lab courses, this situation cannot be tolerated on a long-term basis. Since there will be no significant reduction of students expected until 2020, it is imperative to maintain and ensure the quality and quantity of lab courses through corresponding measures. The „FREI-Project“ can be seen as a flexible and affordable measure, to solve the given quality and quantity problems. FREI is a German acronym for „Fernsteuerung von realen Experimenten über das Internet“ which translates to „remote control of real experiments over the Internet“. It represents a university project developed at the Cologne University of Applied Sciences in cooperation with the Institute of Physics Education at the University of Cologne. The goal of this project is to create an E-Learning portal that offers students at the Cologne University of Applied Sciences, and in the near future also students at other universities, the possibility to remotely control lab experiments through an online portal. The FREI-Project will not replace regular lab classes within the curriculum of the university, but rather complement them. In addition to students carrying out lab experiments in the lab, virtual labs will allow them to carry out real experiments - not simulations - but with computer-controlled actuators instead of hands and webcams instead of eyes. The FREI-Project was established in October 2012 and has been continuously growing since then. Six remotely controlled experiments have been realized in the Institute of Physics and have already been successfully used in the curriculum of several majors for four semesters.

These virtual labs have received positive feedback from the students and lecturers. Around 360 students from the degree programs electrical energy technology, automotive engineering and rescue engineering have already accomplished such a remotely controlled lab course in the summer semester of 2015 through the E-Learning portal of the FREI-Project. The contents offered in the FREI-experiments at the Institute of Physics are targeted to students from the secondary education sector and first year students at the university. The FREI-Technology is used in physics, but can also be used in other majors. With the aid of the FREI-Team, FREI-technology was implemented into a water level control loop in the course of a bachelor thesis at the Institute for Control Engineering and Mechatronics in August 2014. This remotely controlled experiment was successfully carried out by students in September 2014. In January 2015, another experiment was realized through the E-Learning portal for students at the Institute of Agricultural Engineering and Renewable Energies and will be available as of summer semester of 2015. This experiment consists of an apparatus that will enable students to analyze bearing and gear faults through FFT and envelope analysis. Goal of this thesis is to document the development, evaluation and the application of the FREI-Project into the different curricula. The introduction will give a brief insight into the motivation of the FREI-Project and how it can enhance and improve teaching in German universities. After this, the functional principle of remote control will be explained, the basis for all FREI-Experiments. Then an insight into the present state of the art of remotely controlled lab experiments is given. The FREI-Concept and the appropriate technical realization will be dealt with in chapter 3. The technical realization of the FREI-Experiment „mechanical forced oscillation“ will be comprehensively explained in chapter 4. The components used in the experiment, the wiring, the programming with LabVIEW and the website programmed with Adobe Flex will be described in this chapter, which will end with a comparison between the results of the real experiment and the remotely controlled experiment. In the fifth chapter, a comparison between the real experiment and the virtual remotely controlled experiment in terms of knowledge gain will be made. Furthermore, a worldwide investigation concerning the existence of remotely controlled laboratories will be made. Afterwards, an evaluation of the FREI-Project will be presented, evaluated and discussed. Chapter six discribes the usage of new teaching medium's in teaching, presenting the teaching medium „FREI“ and lists it's benefits and disadvantages. The usage of HTML5 for the future remote control through tablet and mobile devices will be discussed in the outlook. The last chapter summarizes the achieved discoveries throughout this study.