It’s Lab Time – Connecting Schools to Universities’ Remote Laboratories

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Abstract
Remote laboratories allow researchers to perform experiments via a normal web browser from any geographical location with internet access. Given the fast technological development and ever higher bandwidth, a growing number of universities and research centers offer their students and/or interested lay persons the opportunity to set the variables of an experiment, execute and retrieve the data for analysis. Furthermore, Rocard [1] summarized studies on the overall effectiveness of an inquiry-based approach to teaching in schools with regards to raised interest in and motivation for science subjects as well as a better inclusion of girls and disadvantaged students. Despite those facts, many schools especially in rural areas have fragmented access to science laboratories or lack proper equipment. Deductive “chalk and talk” methods prevail in many science classrooms, failing to equip students with a proper understanding of scientific inquiry.

The EU-funded project UniSchooLabS addresses these gap and aims at improving quality in science education by promoting collaboration between universities and schools in the provision of remote access to science laboratories for primary and secondary schools through the development of an online toolkit and the deployment of the inquiry-based teaching methodology.

The paper will present the project approach to build a collaboration model for remote labs between schools and universities and the main functionalities of the respective toolkit consisting of a lab catalogue, an inquiry-based student activity editor and a student notebook.

1. Remote and virtual laboratories in science teaching
Remote and virtual laboratories were set-up by universities and science centres in the last 15 year driven by the advances in technology and cost pressures on universities. Virtual laboratories work with computer models and experimentation takes place in the form of a simulation which yields the same outputs as real experimental counterparts. Remote laboratories on the other hand offer direct manipulation of laboratory equipment, by means of an internet browser and a user interface which allows controlling the actual laboratory equipment from the distance. Both types of laboratories provide tools for data acquisition, data display and analysis. They serve to simulate complex phenomena and higher education institutions increasingly deploy labs as part of their distance learning programmes offer to their science students and platforms are getting more mature [1]. Although the majority of remote labs have initially been developed in the area of engineering education, “laboratories are not restricted to a single educational topic” [1, p.2] anymore, e.g. a growing number of laboratories is offered in the field of physics and astronomy.

In a pedagogical context both physical and remote laboratories have advantages and constraints. Traditional laboratories offer real-hands on experiences, but come with a large expense and demands for space and thus limit students’ and teachers’ access to their schools’ equipment. Remote/virtual laboratories allow for access independent from time or geographical position and help to make better use of valuable lab time. Obviously they come with computer limitations. Furthermore there has been
a long-running debate about the value of hands-on versus simulated laboratories, questioning the educational value if students miss out on the hands-on experiences with equipment.

Current studies challenge “the conventional wisdom that students learn more via hands-on experience” (p.7) within a university context [2]. In an inquiry-based teaching setting second semester physics course students using virtual laboratories demonstrated a better mastery of physics concepts and skills than their peers deploying real equipment. Further research with younger learners tested the understanding of causal variables in a discovery approach (by building toy vehicles with different features) among seventh and eighth graders [3]. Also this study showed no difference in performance physical versus virtual material.

2. Remote labs and primary/secondary school classrooms: Existing barriers

Although the above section suggests various reasons for introducing virtual/remote laboratories into school classrooms, there has not been a wide adoption in primary and secondary education. Several hindrances can be mentioned. Firstly, there is a lack of awareness about their existence and accessibility amongst science teachers. Secondly, information on which university labs are suitable for use in primary or secondary school teaching is hard to find and most teaching and learning material of remote labs are neither geared towards younger students of a specific age group nor available in many languages. Thirdly, pioneer teachers making use of remote laboratories in the classroom are not networked. Fourthly, wider adoption demands well-established school university collaboration. Regarding the latter, it is noteworthy that during recent years several networks of universities running remote laboratories emerged. The benefits for universities to enter a cooperation with other higher education institutions are more or less straightforward, i.e. often based on a tit-for-tat agreement to share services among providers to increase lab access for all of their students. Partnerships between schools and laboratory providers, however, are different and – especially in a large scale model - pose many challenges given the cultural boundaries between schools and universities with their diverse interests, resources and power distribution. On the other hand, policy-makers have understood that “school and university partnerships are a key strategy for reforming education” [4, p.28] and successful programmes and initiatives do exist bringing academics and practitioners into closer relationships in order to improve the conditions in local communities, e.g. in pre-service teacher education and continuous professional development or school improvement research.

3. The “UniSchooLabS” project approach

The EU-funded project “UniSchooLabS” aims at improving quality in science education in Europe by promoting collaboration between universities and schools in the provision of remote access to science laboratories for primary and secondary schools through an internet-based service. The project has also been designed around the idea of success being dependent on the pedagogically context within which remote laboratories are used and thus, inquiry-based learning will be promoted as an up-to-date approach to science education. Inquiry-based science education has been proven to raise curiosity in science, interest, motivation and self-esteem among students and showed positive effects on learning outcomes with disadvantaged students and those with below-average performance [5]. Furthermore, project activities were planned with early involvement of potential beneficiaries as teachers and laboratory owners. Initially it was researched which high quality remote laboratories and related (pedagogical) practices do already exist. Based on those results an online toolkit for teachers was developed in order to overcome the above hindrances of using remote lab in school classrooms. Teacher of 10 selected pilot schools in 4 different countries received a short training on inquiry-based science education and were involved in toolkit content development. In order to receive formative feedback from target users and improve the effectiveness and usefulness of the developed tool it is
then tested in the science classrooms of the respective schools and validated by laboratory owners. As a next step further teachers are trained in toolkit use and the collaboration model is presented to further stakeholders, namely science communicators in the informal learning sectors, policy-makers and headmasters in primary and secondary schools. In structured workshops the feasibility of a permanent coordination structure of school-university collaboration in science education is explored. Subsequently, the project will produce a set of policy recommendations based on results of the project activities and will make them accessible to European and national policy-makers.

The UniSchooLabS partnership is composed of five partners in three different countries bringing together a) research expertise on ICT in learning settings and technology enhanced learning b) service provision to schools especially in the field of ICT and science education as well as c) networking and sustainability building for innovation in higher education.

4. Using remote labs in the classroom: A toolkit for teachers

The toolkit functionalities are designed to ease access for teachers to remote and virtual science labs and support the use of inquiry-based science teaching. A lab catalogue lists nine of remote and virtual laboratories clusters covering the science fields of physics, astronomy and chemistry selected on basis of a good practice analysis according to the following criteria: existence of learning and teaching material, low access thresholds (registration, required software) from outside of the providing university, prior documented use in primary or secondary school classrooms and multilingual user-interfaces. A lesson activity editor gives teachers the opportunity to create and share lab-related classroom activities for students. Those can be browsed sorted by laboratory. Through a tool-kit...
notebook students can publish results of experiments and discussions. Supportive features aid users getting started with the toolkit. Four different example activities have been prepared for direct use in the classroom as well as an introduction to inquiry-based learning and a technical help section with step-by-step guides on how to make best use of the toolkit. In order to, promote peer learning and ensure systematic support from the project partners hip, an online community has been launched.

Fig. 2. UniSchooLabS toolkit: Inquiry-based lesson activity making use of a remote telescope

5. What is next? Pilot results and steps to set up a larger scale provider-school collaboration

The methodology for evaluating the toolkit in its intended context (pilot testing) is grounded on indicators of success for introducing innovative technology into education, such as empowerment of educators, suitability and usefulness to both laboratory providers’ and teachers’ needs, acknowledgment of innovative features, universality and potential for transfer to other national or school contexts and mainstreaming. Through questionnaires, focus groups and interviews we will gain knowledge under which external conditions the toolkit and its support services provide the highest value to teachers and students including school location (remote versus urban school), age of students, accessibility of physical hands-on labs, frequency of practical science work in class and teachers’ prior experience with IBSE framework. The study will also obtain insights whether collaboration with schools is perceived as added value by lab owners and what cost models might be adopted on a larger scale.

With these results on hand workshops are organized addressed to school headmasters, teachers, university laboratory providers, policy makers and science communicators. Those are designed to foster typical characteristics found in successful collaborations between schools and universities [6], which can be clustered into three different categories:

A Shared vision and attitudes

- Mutual self-interest and common goals
• Clear focus: strong consensus regarding the outcome, a vision of the new organisation to be created and its mission.
• Mutual trust and respect: all parties recognize and utilize the talents and perspectives of each participant
• Long-term commitment

B Establishing working procedures
• Shared decision making, from goal-setting to operations.
• Manageable agenda: mapping activities so that all are aware of how their efforts and the efforts of others contribute to the outcome.
• Dynamic nature: members have the opportunity to revisit plans, incorporate new understandings and ideas, and change priorities as experiences dictate – having a map rather than an itinerary.
• Information sharing and communication.

C Support structure
• Commitment from top leadership.
• Fiscal support.

The evaluation study and workshop results will give input to craft a large scale “UniSchooLabS” collaboration model connecting schools, laboratory providers and other science communicators.

References