STEM Education: A Remote Laboratory Implementation in Physics Courses

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Abstract. In 2020, due to the pandemic and lockdowns, upper secondary schools and universities worldwide rapidly transitioned classes and activities to be conducted remotely. This transition presented particular challenges for laboratory courses in science education. The study presented here was carried out in a higher education institution and an upper secondary school in Sweden in three different courses where a remote laboratory VISIR addressing electric and electronic topics was implemented. The data collected from 254 students' activities and teachers' experiences of the factors affecting the usage of the VISIR during implementation are presented.

Introduction

Unfortunately, in remote schooling situations, as we witnessed them during the Covid-19 induced school closures, students cannot be guided by the teacher in the same way as during regular (i.e., face-to-face) schooling; rather, students are required to self-regulate their learning to a larger extent. In [1], results are reported from a survey of laboratory instructors on how they adapted their courses in the transition to emergency remote teaching due to the COVID-19 pandemic. Additionally, during remote schooling, hands-on experiments for inquiry learning cannot be performed as usual; rather, experiments need to be implemented differently. Digital technologies allow for either virtual experiments (interactive computer simulations), or video experiments (videotaped real experiments), which can be combined to offer complementary affordances. The authors in [2] conclude that for STEM education virtual and video experiments can be recommended to teachers if hands-on experimentation is not possible

The present paper focuses on the use of remote laboratories (RL) in STEM education from a didactical viewpoint. Integrating RL into the design of teaching activities may better allow students to pilot their learning to achieve the desired outcomes. Learning requires student participation. In distance physics courses during 2012 and 2013 at Blekinge Institute of Technology (BTH) the teacher introduced an optional assignment to use the remote laboratory: Virtual Instrument Systems in Reality (VISIR) to wire electronic circuits without having to be on-site. Furthermore, in two physics courses at upper secondary school Katedralskolan in Lund, Sweden [3], that suddenly became distance based courses due to Covid-19, the students could still perform laboratory assignments to fulfil the courses syllabus, but now remotely.

The VISIR laboratory [4] at BTH, Sweden, is an architecture for opening hands-on instructional laboratories for remote access 24/7 with preserved context. The VISIR project started at BTH in 1999, under the initiative and leadership of Ingvar Gustavsson.

This study aims to answer the question: “How can remote laboratories be used as a didactic choice to increase interest in STEM subjects?”. Furthermore, it presents research findings that encompass experiences during the COVID-19 pandemic.

Courses

VISIR was used in courses titled Physics for Product Development, Physics 1 and Physics:prep, for the electronics parts (electric charge, field strength, potential, voltage, current and resistance), as shown in Table 1.

Table 1. Overview of the courses

Year	Course	University/ Upper secondary school	Number of students	Distance (D) Distance due to COVID-19 (D19) In campus (C)
2012, 2013	Physics for Product Development	BTH	68	D
2016 - 2019	Physics 1	Katedralskolan	154	C
2020, 2021	Physics:prep	Katedralskolan	32	D19

Methods and findings

A mixture of resources were used in laboratory classes on-site at school; hands-on, simulations, and remote laboratory VISIR. During distance courses the only method used for experimental work was the remote laboratory VISIR. In the courses, the teachers introduce remote laboratory VISIR to students before starting the actual work. Google Meet or other web conferencing platforms providing screen sharing have been used for supervised laboratory sessions or to perform experiments together with others using RL.

It is good to have a hands-on session on-site before the students use the remote laboratory VISIR. The students can then test wiring and instrument settings. With distance students, this is only possible via web camera. The majority of the students were satisfied with VISIR, and appreciated that they were not simulations but happened in real life.

Conclusion

In general, students encounter some difficulties when they start using the system. If the teacher does not provide assistance and encouragement in overcoming this initial barrier, the probability of dropping out increases. The evaluation shows that more work can be done with the introduction of the VISIR. The results from the questionnaire also show that the students are not convinced that the measurements are from real equipment and not from simulations. This implies that more work can be done with the VISIR interface.

The students showed great interest in the laboratory work. The number of VISIR accesses per student shows that four are enough to fulfil the experimental work and hand in a laboratory report.

References

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