Work in Progress: How Real is Student Engagement in using Virtual Laboratories

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***Abstract* - Laboratory classes are an integral part of engineering education, but they are resource intensive and can also impose significant logistical constraints upon the curriculum. One option to reduce these burdens is the use of virtual laboratories – where students do not interact with real hardware, but rather with computer simulations of laboratory equipment. A key issue in virtual laboratories is the issue of the authenticity of the learning experience. It is imperative that the students interact with these laboratories in a way that is reflective of the hardware being simulated. However, there is the potential for students to lose sight of the underlying hardware, and instead get caught up in the "computer game-ness" of the experience. The degree to which students are engaged in the type of cognitive processes used by practicing engineers is critical to how they construct their learning within the virtual laboratory, and as such can dramatically impact the overall learning outcomes of the class. This WIP paper presents a multi-site study investigation into these outcomes involving four different virtual laboratories at four different universities.**

Index Terms – Evaluation, Laboratory Classes, Learning Outcomes, Virtual Laboratories

INTRODUCTION

Laboratory classes target a range of different outcomes [1] in a way that is not possible in the lecture or tutorial mode of teaching. Recently remote and virtual access to laboratory classes have become more prevalent as alternatives to the traditional proximal experience [2]. With this shift to virtual hardware, however, comes a change in the learning experience of the students.

Virtual laboratories replace the physical hardware with a computer-based representation, leading students to engage differently with the hardware. This difference has the potential to undermine the educational value of the learning experience – if they engage on an artificial, contrived level, rather than on a deep, authentic level, then their laboratory experience will not be a meaningful learning experience.

This WIP paper presents a multi-site study investigation involving four different virtual laboratories at four different universities across Australia and the USA:

- Embedded microcontroller with peripheral boards
- Semiconductor manufacturing process
- PLC control of pneumatics
- Axial load testing

The study focuses upon the extent to which students need to perceive a virtual laboratory as being real for it to be effective.

THE RESEARCH QUESTION

In order to ensure that a virtual laboratory class feel real to the students it is necessary to determine which aspects of the class contribute to that sense of reality. Our key research question is thus:

"Which elements are critical in establishing authenticity in a laboratory, and how can these be achieved in a virtual laboratory context?"

This key research question has been further refined into a number of sub-questions, each of which deals with specific aspects of the virtual laboratory context:

Establishment reality vs maintenance reality.

There is the potential for the level of verisimilitude required of the simulation to vary throughout the stages of student contact. At first contact, the students are familiarizing themselves with the equipment, and need access to a wide range of different viewpoints of the equipment – the breadth of interaction is important. As students utilize the virtual laboratory more, they interact with only a small subset of the equipment, but they do so in more sophisticated ways – the depth of interaction is important. The balance between early breadth and later depth, as well as the value of adding early depth or later breadth, forms one aspect of our investigation.

Addition vs Substitution

The inclusion of a simulated laboratory is within the curriculum occupies a place that could potentially have been occupied by a "real" laboratory. For some experiments this replacement is feasible, in which case the simulated laboratory represents a substitution into the curriculum. For other experiments, such as simulations of expensive and hard-to-access equipment, the simulation represents an addition to the curriculum that would otherwise be impossible. The students'

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preconceptions about whether the virtual laboratory is a bonus opportunity, or a second-best substitute, will impact their engagement with the laboratory, and are a focus of our research.

Interface transparency

One of the key outcomes of the laboratory learning environment is the ability to deal with experimental data that does not match the predictions. These discrepancies are not uncommon in the real laboratory environment, but within a simulation laboratory, there is one additional potential source of error – the simulation itself. If the students respond to unexpected data by questioning their predictions, or double checking their settings, it shows that they are engaging with the laboratory as if it were real. If, however, their response is to ask the demonstrator whether the simulation is wrong, this shows that they have not fully engaged with the laboratory, and the virtual nature of the experience is overlaid over their experience.

THE METHODOLOGY

A range of tools are being applied to measure the learning outcomes of the virtual laboratory classes:

Think Aloud Protocol

The "Think Aloud" protocol has already been applied to one of the four virtual laboratories [3], allowing for the students' metacognition of their learning to be captured. This tool allows for their reflections – both during and after the laboratory – to be measured, as well as to gauge their ability to cope with the ambiguities of the experimental environment.

Surveying the students

Explicitly surveying the students is an efficient way of capturing their perceptions of the laboratory. Surveying the students also allows their perspectives of the objectives of the class to be measured. Previous work [4] has shown that there can be dissonance between what students felt they were meant to be learning, and what they thought were actually learning, and so it is important to measure both.

Data Logging

The most effective way to access information about how the students are interacting with their equipment is simply to log these interactions. This allows the interactive aspects of their laboratory practice to be analyzed, and for patterns of access to be identified.

Assessment Tasks

It is important that the laboratory actually meets the educational needs of the students. The assessment tasks will determine whether this is in fact occurring. Patterns in the assessment outcomes – for example, if there are particular concepts that are consistently misunderstood – will provide some insight into which areas are being emphasized to the students by the simulation.

PROGRESS

The measurement tools have been developed, and applied to student cohorts undertaking virtual laboratories at the four institutions involved in this study. Full analysis of the data is yet to be completed as of the submission of this paper, however initial analysis is promising:

- Differences in the way students engage with the laboratory as novice users in the first instance when compared with their engagement as proficient users.
- Differences in student motivation dependent upon whether their virtual laboratory is a "substitution" or an "addition" to the curriculum.

Collation of the data will allow for more in depth analysis to be performed, as well as cross-institutional comparisons between the four study sites. This process will lead to an improved understanding of how students build their reality in a virtual laboratory class.

REFERENCES

[1] Feisel, L. D. and Rosa, A. J., "The Role of the Laboratory in Undergraduate Engineering Education," *Journal of Engineering Education*, vol. 94, pp. 121-130, 2005.

[2] Ma, J. and Nickerson, J. V., "Hands-On, Simulated, and Remote Laboratories: A Comparative Literature Review," *ACM Computing Surveys*, vol. 38, 2006.

[3] Koretsky, M., Amatore, D., Barnes, C., and Kimura, S., "Enhancement of Student Learning in Experimental Design using a Virtual Laboratory," *IEEE Transactions on Education*, vol. (Accepted), 2007.

[4] Lindsay, E. D. and Good, M. C., "Effects of Access Modes Upon Students' Perceptions of Learning Objectives and Outcomes," presented at 15th Annual Conference for the Australasian Association for Engineering Education, Toowoomba, Australia,, 2004.