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Designing Remote Labs for Broad Adoption

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Abstract— **If learning technologies such as remote online labs are to achieve broad adoption, it is imperative that we take seriously the needs of the instructor and the real world context in which he or she will use these resources. Here we describe efforts to address the many barriers to successful adoption of remote lab technologies in secondary school settings. An iterative, design-based research process that includes close collaboration with classroom teachers has produced a more robust and user-friendly platform with several unique new capabilities.**

Keywords—remote online labs, scientific inquiry, STEM education, learning technology, user testing

A primary rationale for research and development in online lab technologies is their promise in increasing access to high-quality science and engineering education [1]. Yet, to date, the field seems to be focused on addressing the many technical challenges involved in implementing online labs, creating platforms for sharing labs, developing standards for interoperability and integration with learning management systems, e.g. [1-2]. These are certainly important efforts that must be addressed as the field continues to mature but not at the expense of the needs of 'real' end user of online labs in engineering education: the instructor [1]. We know that lab experiences, whether they be traditional hands-on, simulated, or online, are primarily used within the context (i.e., the "use case") of a course (either in person and online). Thus, as the field continues to develop online lab technologies with the goal of integrating them into engineering education, it is imperative that we take seriously the needs of the instructor and the real world context in which he or she will use these resources. Some research questions (RQ) that we are currently investigating include:

RQ1) What specific functionality is required to make instructors comfortable in adopting online labs in addition to or in place of traditional labs?

RQ2) In what ways can online labs improve the pedagogical value of lab investigations?

RQ3) How can online lab tools reduce the administrative overhead associated with traditional lab investigations?

RQ4) How can we best support instructors in recognizing these pedagogical and administrative benefits in order to increase adoption rates?

Surprisingly, there is very little in the online lab literature that examines these questions. Perhaps this is part of the natural evolution of a relatively new technology like online labs, but it points to a critical need that must be addressed for online labs to achieve broad adoption. Conclusions

In this paper we introduce three features intended to make instructors more comfortable in adopting online labs, improve the pedagogical value of lab investigations, and reduce the administrative overhead associated with them. By tackling these challenges that most affect the instructors who are the ultimate gatekeepers to broad acceptance of online lab technologies we seek to ultimately increase adoption rates for online lab platforms while increasing the pedagogical benefits to students.

Managing a lab investigation can be a complex and time-consuming task for instructors. Not only can this complexity contribute to hesitation on the part of instructors to incorporate additional labs, but it can also serve to undermine many of the benefits labs are intended to provide. For example, [3] found that in order to manage the complexity of numerous lab groups, teachers tended to give strong guidance to keep each group from diverging too far from the others. This, unfortunately, enforces similarity through procedural instructions and worksheets, limiting opportunities for true student-driven inquiry and for the analysis of variability and the consequences of different experimental designs.

Supporting student-driven inquiry and experimentation can be very effective in terms of learning gains. However, as [3] points out, this diversity of student activity can be intimidating for an instructor to manage. In addressing RQ1 and RQ2 above, we seek to reduce instructor reluctance to include lab investigations in their curriculum and to help support the pedagogical goal for student-driven inquiry that lab experiences should ideally provide. We have also strived to address the monitoring needs of instructors through a dashboard feature that enables better monitoring of student progress in completing assigned labs and analytics to provide better insight on student progress.

In order for instructors to willingly integrate new activities into their curricula, they need the ability to easily adapt it to meet their own individual teaching goals and to fit in with the needs of their students. Cookbook activities do not leave room for instructors to "meet students where they are," a pedagogical practice that aids in constructivist learning. Our new remote labs authoring tool is designed to have maximum adaptability to ensure that instructors have the functionality they need to easily build their own remote lab journal. Modular steps are created or adapted from existing examples, and built into an activity with scaffolding appropriate to each classroom's needs.

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Group Assignments | Individual Assignments

	Group	Student	Lab Journal Name	Assigned Date	Due Date	Start Date	Status	% Complete	Last Modified	Grading Status	Grading % Complete	Time Spent (HH:MM:SS)	Grade
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	Biology Period 8	Cohen Young	Cell Phone Radiation (KJ Biology P8)	06/02/2014	06/09/2014	06/09/2014	In Progress	50	06/10/2014	N/A	0		View
	Physics Period 1	Maya Evans	Mission to Mars: Radiation Shielding (KJ Physics P1)	06/02/2014	06/09/2014	06/02/2014	Feedback Received	100	06/03/2014	Sent to Student	100	0:03:42	View
	Physics Period 1	Caleb Hernandez	Mission to Mars: Radiation Shielding (KJ Physics P1)	06/02/2014	06/09/2014	06/03/2014	Submitted	100	06/03/2014	New	0		Grade
	Physics Period 1	Noah Martin	Mission to Mars: Radiation Shielding (KJ Physics P1)	06/02/2014	06/09/2014	06/03/2014	In Progress	72	06/03/2014	N/A	0		View
	Physics Period 1	Daniel Miller	Mission to Mars: Radiation Shielding (KJ Physics P1)	06/02/2014	06/09/2014	06/03/2014	Submitted	100	06/03/2014	New	0		Grade
	Physics Period 1	Cohen Young	Mission to Mars: Radiation Shielding (KJ Physics P1)	06/02/2014	06/09/2014	06/03/2014	Feedback Received	100	06/03/2014	Sent to Student	100	0:07:12	View
	Biology Period 8	Caleb Hernandez	Cell Phone Radiation (KJ Biology P8)	06/02/2014	06/09/2014	06/03/2014	Submitted	100	06/03/2014	New	0		Grade
	Biology Period 8	Noah Martin	Cell Phone Radiation (KJ Biology P8)	06/02/2014	06/09/2014	06/03/2014	In Progress	16	06/03/2014	N/A	0		View

Fig 1. Teacher Dashboard feature

Formative or evaluative questions can be created by the instructor or selected from a bank of existing questions through a drag and drop feature. Student monitoring can be accomplished through the dashboard feature at either a class or individual student level. These innovations are a great improvement over previous remote lab experiences in that the added functionalities address many of the common concerns previously cited for not using remote labs in a classroom.

Educative materials [4] are embedded into the authoring tool in order to help instructors improve the pedagogical value of their lab investigations. Information is provided to aid instructors in crafting inquiry-driven lab activities for their class in the form of example lab journals developed by curriculum development specialists. Steps are described in terms of learning goals for each type in order to provide instruction on how and when to employ each. Example questions and metacognitive prompts are included along with teacher notes that explain not only correct answers, but also why the question was included and how it supports student learning.

A monitoring dashboard (Fig. 1) and feedback tool are integrated into the authoring tool in order to help reduce the administrative burden that can prevent instructors from including lab activities their curricula. The monitoring capabilities of the teacher dashboard are a desired functionality to make instructors comfortable in adopting remote labs but also serve to reduce the amount of papers to keep track of, messages sent to check in with students, and the other logistical details required for paper based assignments. The feedback tool allows instructors to efficiently provide detailed, quality feedback both improving pedagogy and reducing the time required to evaluate student assignments.

Supporting instructors in recognizing these benefits and ultimately increasing adoption rates will be accomplished by emphasizing the aspects found during this process to be most appealing to teachers. The ability to adapt a lab to the level of their students and the time available for the activity is appealing, along with the reduced amount of time needed for lab preparation and administration of assignments.

NEXT STEPS

Data is currently being collected on how the tool is being used in the field, and whether the interface successfully addresses the needs of teachers enough to increase adoption rates. Additional studies will be conducted to compare the efficiency of remote labs to traditional hands-on classroom activities in terms of both preparation and evaluation. Necessary adjustments will be made to the interface before a formal launch of the platform in 2015.

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REFERENCES

[1] T. de Jong, M.C. Linn, and Z.C. Zacharia, "Physical and virtual laboratories in science and engineering education," Science, vol. 340, no. 6130, pp. 305-308, 2013.

[2] E. Sancristobal, M. Castro, S. Martin, M. Tawkif, A. Pesquera, R. Gil, G. Díaz, and J. Peire, "Remote labs as learning services in the educational arena," IEEE Global Engineering Education Conference (EDUCON), pp. 1189-1194, 2011.

[3] A. Tiberghien, L. Veillard, J.-F. Le Marechal, C. Buty, "An analysis of labwork tasks used in science teaching at upper secondary school and university levels in several European countries," Science Education, vol. 85, pp. 483-508, 2001.

[4] E.A. Davis, and J.S. Krajcik, "Designing educative curriculum materials to promote teacher learning," Educational Researcher, vol. 34, no. 3, pp. 3-14, 2005.