Don't Forget the Teacher: New Tools to Support Broader Adoption of Remote Labs

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***Abstract*—In order to support broad adoption of remote labs in elementary and secondary schools, we need to provide powerful, easy-to-use interfaces, not just to students, but also to teachers. We are developing tools to provide richer, technology-supported representations that improve teachers' ability to visualize student remote lab activities and diagnose misconceptions with the goal of maximizing remote lab's educational value and impact.**

***Index Terms*—remote labs, user interface design, data visualization, learning analytics.**

I. Introduction & Research Context

If we want cyberlearning tools like remote labs to achieve their full potential, particularly as we seek to expand their use in elementary and secondary settings, it will not be enough for us to design tools that can improve student learning outcomes under relatively ideal circumstances [1,2,3]. The history of educational technology is littered with innovations that seemed promising, but failed to achieve widespread use or impact [4]. The problem is that it is not enough to have technologies that are a good fit to the needs of *learners*. We also need technologies that are a good fit to teachers and schools (at least as they are currently construed). Remote labs must be practical to employ, and they need to fit within the broad range of real-world contexts in which science and engineering learning occurs. In order to produce impact at scale, remote labs need to better support their own use by teachers and schools.

One of the tasks that teachers face, across all types of instruction, is to monitor what students are doing, and to provide feedback that guides student learning. When all students in a class are doing precisely the same thing, these tasks are comparatively easy. However, when instruction takes the form of student-driven inquiry – inquiry of the sort that is made possible by cyberlearning tools – these tasks become dramatically more difficult. We know that integrating inquiry into classrooms is difficult for teachers [5]. Without sufficient support, teachers often have no choice but to constrain student inquiry to a single path [6]. Thus, we believe it is imperative to develop solutions to challenges faced by teachers when they use remote labs to support student-driven inquiry, a type of activity that teachers find to be among the most challenging to manage [7,8].

When student inquiry is supported, at least in part, by cyberlearning tools like remote labs, there may be some technological solutions to these problems faced by teachers. When the work of students leaves digital traces, we can seek to mine some of this information, and to present it in a form that allows teachers to monitor students, and to more easily provide feedback and guidance. The design problems here are non-trivial: we have to develop mechanisms for students to leave more interpretable digital traces by making their thinking more explicit, craft algorithms that extract useful information from the digital traces left by students, and we have to figure out ways of presenting this information to teachers so that it supports their efforts and integrates into classroom routines and structures, rather than just adding to the information overload. *We argue that introducing richer, technology-supported representations that improve teachers' ability to visualize student remote lab activities and diagnose misconceptions individually or class-wide will improve teacher effectiveness and productivity, and maximize the value and impact of remote labs and other cyberlearning tools*. Moreover, by leveraging usage data from across all student and teacher users, we believe that it is possible to create tools that could be especially helpful in enabling novice teachers, or those who do not have as strong a background in a particular science or engineering field, to provide better and more appropriate feedback to their students.

II. Tools to Support Teacher Implementation of Remote Labs

Remote labs can't be designed only for use under "ideal" circumstances; it has to be feasible for teachers to make these tools work given the larger set of logistical challenges they face in their classrooms [9,10,11]. A major obstacle for teachers in adopting remote labs that are designed to allow for more student-directed inquiry in their science classes is the difficulty of effectively managing many students all working independently or in small groups on investigations [7,8].

Our goal is to develop tools that harness the collective intelligence of teachers and use the automated intelligence of learning analytics we are developing to reduce the cognitive load on teachers, improve the representations available to them of the aggregate state of their class, and eventually to point them to specific student difficulties in learning with remote labs. *We hypothesize that effectively managing teacher workload will be a critical factor in teacher adoption of remote labs and cyberlearning tools more generally.* These new tools, if successful, will begin to help us understand how to not only leverage cross-student, cross-classroom data, but also how to best represent it to teachers to enhance their professional vision [12,13] and ultimately the quality of their teaching.

Our current work focuses on three areas:

1) A teacher dashboard that enables better monitoring of student progress in completing assigned labs and analytics to provide better insight on student usage.
2) A feedback assistant that supports teachers in providing better and faster feedback on student remote lab work.
3) An authoring interface that supports teacher adaptation of remote lab activities to better fit their local curriculum goals and sequencing.

(1) Teacher Analytics Dashboard. We are developing a teacher dashboard for monitoring student progress during remote lab investigations that will provide simple descriptive statistics on student use of the lab (e.g., who has started working on the investigation, who has completed it, total usage time, etc.). This dashboard will also support the teacher assignment- student work product submission-teacher feedback cycle between teacher and students. Specifically, it will indicate which students have submitted their online lab journals for feedback, enable the teacher to launch the feedback tool (described below), see which students have been provided feedback, and whether they have resubmitted their lab journals with requested changes.

We are also developing a set of analytics focused on student experimental design parameters. Because the system stores the parameters each student uses for every experiment submitted, it should be possible to develop analytics that will highlight for teachers those students whose experimental designs are weaker (e.g., few data points, limited replications). The goal is to be able to flag those students who require additional teacher support.

(2) Feedback Assistant. Building on similar work on a *Java Critiquer* [14], earlier work by [15], and a broader research literature on critiquing systems (reviewed in [16]), we are implementing a "feedback assistant" that lets teachers select from a library of standardized feedback tailored to a specific remote lab investigation. We are working with partner teachers to write feedback statements that correspond to a set of typical answers that students give to the prompts in their online lab journals.

Rather than requiring teachers to manually write (and rewrite) constructive feedback for each student response across all 30-100 students a teacher typically has in his or her classes, this "feedback assistant" will streamline the teachers' task by replacing manual feedback entry with the selection of a pre-authored piece of feedback. (In cases where no existing feedback is found to be appropriate, the teacher can add a new tailored response that then is added to the feedback library for future reuse.) This simple tool can dramatically reduce the time burden on teachers of providing individualized feedback to students. In addition to being useful to teachers directly, this tool will also enable data collection to support more sophisticated analytics making the tool even more useful to teachers. Specifically, we envision that the system will be able to aggregate which feedback items are utilized most frequently for a given class, providing the teacher with a better view of conceptual misunderstandings that may be shared by the entire class, or key subsets of students. If only a few students are struggling with a concept, this indicates that a targeted intervention by the teacher is called for. If most or all of the class is struggling (based on feedback provided by the teacher), this instead may warrant re-teaching the concept to the whole class.

(3) Supporting Teacher Adaptation. A critical element in enabling any cyberlearning tool to be scalable and sustainable is local teacher adaptation [1,2,3]. To this end, we are developing an interface that allows teachers to author their own investigations based on existing remote labs. Teachers can author customized lab journal prompts, so that when their students use the remote lab, they are guided through the inquiry process by question prompts created by their teacher. We enable teachers to "publish" their lab journals for other teachers to use, or elect to keep them private for use only by their own classes. By distributing the authoring process to our community of teachers, we support local teacher adaptations and enable a much greater range of applications for each remote lab we bring online.

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