MicroTracker: a Data Management Tool for Facilitating the Education of Undergraduate Students in Laboratory Research Environments

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INTRODUCTION

There is currently in the United States a nation-wide effort to strengthen education in the areas of Science, Technology, Engineering, and Mathematics (STEM); thus, the need for quality laboratory-based research education at the undergraduate level has never been more important. However, many undergraduate laboratories are, too often, little more than an exercise in “cooking” where students are instructed step-by-step what to add, mix, and, most unfortunately, expect as an outcome. Although the shortcomings of “cookbook” laboratories are well known, they are considerably easier to manage than the more desirable inquiry-based laboratories. For example, in an inquiry-based laboratory, the teacher/mentor must regularly access each student’s research data (experimental results, photos, notes, etc.) in order to track progress, quality of work, and to plan future experiments with their students. Similarly, the same problem of data access and analysis logically extends to student–student collaborations where each student must also be able to access the data of their fellow students in order to perform their part of the research collaboration. Thus the ability to quickly access, share, sort, and analyze research data would make a significant contribution towards the feasibility of teaching/mentoring large numbers of inexperienced students in an inquiry-based research environment, as well as facilitating research collaborations among students. Herein we report on a software tool (MicroTracker) designed to address the educational problems that we experienced with inquiry-based research education due to constraints on data management and accessibility.

MicroTracker was built upon the logical data flow of collecting and processing a sample from which items are retrieved – an architecture common to microbiology, biology, and other fields of research. Other data entry forms in MicroTracker interface with this backbone, allowing users to archive diverse types of data (Fig. 1). A more detailed description of MicroTracker’s design, its functions, a help manual, installation instructions, video tutorials, and a free downloadable copy of MicroTracker is available via the ‘MicroTracker’ link at http://ralab.utpa.edu/.

PROCEDURE

Procedural recommendations for MicroTracker are based on its use at the University of Texas-Pan American (UTPA) during two semesters with undergraduate students participating in an inquiry-based teaching laboratory (IBTL) in Biochemistry (being developed around Bacillus thuringiensis), and for approximately two years with undergraduates performing extracurricular research in a university research laboratory (URL). Key procedural steps are:

♦ Users should ask the IT department to put MicroTracker on a network share. This will allow multiple students...
to use MicroTracker simultaneously. (The website has instructions on how to do this.)

- The Teacher/Mentor needs to configure MicroTracker for their specific needs (project names, experimental protocols, etc.). MicroTracker has a bank of ‘Administrator’ videos on its website that shows the Teacher/Mentor what needs to be configured and how to do it.

- The Teacher/Mentor shows students how to use MicroTracker for their research project. This is best done by showing the student how to enter the first record, after which the student can use that record as a guide/template, along with the ‘auto-fill’ function to quickly enter data (MicroTracker has a bank of ‘User’ videos that shows the student how to perform this and other key functions in the program.).

- The Teacher/Mentor instructs students to always run the ‘Student Report’ on their data after they enter it as a means of verifying that data was entered correctly.

We found that students participating in URL research should always be given short-term goals (one week worked well for us), and IBTL students should be given project ‘milestones’ as a means of guiding student progress. Teachers/Mentors can then use MicroTracker’s ‘Student Report’ to obtain a concise summary and view of the student’s data/progress over the goal/milestone period. We found that this approach worked very well for teaching/mentoring large numbers of research students, and for confirming progress and identifying students who were struggling.

CONCLUSION

After initial instructions by the Teacher/Mentor, URL students quickly mastered the use of MicroTracker via student–student instruction, which did not occur with IBTL students. IBTL students were notably less likely than URL students to ask assistance from other students, presumably because they did not have a history of working together. This problem was most effectively remedied by asking the more established URL students to help the IBTL students, which had the added benefit of promoting a desirable environment of general student–student mentorship.

Both in the URL and the IBTL, MicroTracker provided noticeable savings of time and allowed for better Teacher/Mentor interaction with the student. By using the report functions in MicroTracker, the Teacher/Mentor was able to keep up with the daily activities of both URL and IBTL students, as well as the overall progress of their various projects. Thus when students arrived for their weekly meeting, their Teacher/Mentor was already familiar with their activities/data and was prepared to discuss the student’s data and future activities. As a result, typically only approximately 10 minutes were needed for productive and efficient meetings, thereby making weekly meetings with each student feasible.

MicroTracker also proved very useful in uniting large, multistudent projects where collaboration between different students was required. For example, students isolating bacteria from hospital samples would enter their data into MicroTracker, which was then accessed by other students to identify bacteria for use in antibiotic sensitivity testing, and again by others for species identification and toxicity testing. Thus, although there were numerous students working on different aspects of the same research project, they all had constant and immediate access to each other’s data, thereby facilitating one large cohesive research team.