Research Project Title: Bridging the Gap Between Traditional and Open-Inquiry Based STEM Education: Development of a Guided-Inquiry Web-Based Learning Tool

Purpose/Background: The immediate goal of this effort is to develop a web-based learning tool that: a) is available a non-proprietary model for the development of multiple content-specific virtual experiments, b) can be adapted to any STEM discipline at any grade level as a guided-inquiry learning tool, c) can provide schools with limited teacher and classroom resources/funds a mechanism to engage in guided-inquiry type instruction, d) aids in the development of student metacognitive skills, e) can be implanted in conjunction with ‘hands on experiences, f) is conducive to team-based learning practices, and, g) serves to promote lifelong learning through flexible steps of inquiry. The tool will be developed using a microbiology question as the experimental context, but will the foundation will be adaptable for use in many other life and physical sciences. Once the model experiment is complete, the tool will be evaluated for learning efficacy by local high school teachers.

Description of Project (progress to date): The contextual framework of the model (high school/introductory college level) experiment in microbiology has undergone refinement for clarity. Background (resource) information for the experiment is being collected and a basic ‘storyboard’ for the experiment and all of the user-driven variations has been produced. The collection of digital images necessary for all variations of the experimental results will begin soon. The general mechanics of the software program have been outlined to provide a simulated and interactive experiment where users will have to make choices and interpretations, always having the opportunity to go back a step if they’re unhappy with the experimental outcome. Software programming will begin in late spring, once a suitable engineer has been identified. A quantitative assessment instrument (LORI – Learning Object Review Instrument) has been selected for the evaluation of the software. Quantitative assessment tools (interviews and surveys) are under development.

Our proposal was to develop a web-based learning tool and in the goals section we identified these two sub-goals: c) can provide schools with limited teacher and classroom resources/funds a mechanism to engage in guided-inquiry type instruction, d) aids in the development of student metacognitive skills, e) can be implanted in conjunction with ‘hands on experiences. Although not mentioned specifically in the proposal (an oversight, clearly), we failed to mention that beyond the web framework of this program’s guided inquiry efforts to attain these goals which is primarily text-based, that we would also be developing a visually rich environment that would allow students to observe the results of their choices, evaluate them based on scientific criteria, and allow them to further their choices in their experimental plan. While text-only descriptions of the data could be written sufficiently for students to make evaluations, they are no substitute for information presented visually for interpretation. Similarly, techniques can be described step by step, but often the nuances of the manipulations are overlooked in text, but can be observed in visual presentation by the viewer. Moreover, we envision the users being asked to evaluate the techniques they have chosen to employ through the guided model for accuracy. Such evaluations are limited by text-only descriptions. Materials and equipment, in addition to specific area expertise, are often limited in the classrooms we’re aiming to reach, and so this is an important part of the overall package that we have envisioned and are apt to be a far more engaging aspect of the multi-media web-tool, thus promoting engagement, excitement and a well-simulated ‘hands-on' experience for the users.

At the time of the proposal, we had intended to utilize digital photography/videography equipment owned loaned by the Department of Microbiology to high resolution images and short video segments which demonstrate techniques that they can employ in their experiments in order to produce a very visually rich
multimedia learning tool, but found that the equipment did not produce the resolution that we were aiming to achieve. The low resolution images that we could capture would have made it difficult for users to evaluate effectively, lead to incorrect conclusions in the overall guided experiment, and take away from the overall impact that we’re hoping to produce. Thus we requested a budget re-allocation to allow us to purchase a new system to be used in this endeavor: Nikon D5000 DX-Format Digital SLR Camera Two-Lens VR Outfit (18-55 VR & AF-S DX VR 55-200mm F4-5.6G). This request was granted, and the equipment ordered, in May, so no images have been captured for the project at the time of this report.

**Data Collection and Analysis:** No data has been collected at this time because the tool is still under design. However, we have identified LORI as our instrument for a quantitative evaluation on student learning. LORI was specifically designed to evaluate multimedia learning resources and measures impact on nine dimensions: content quality, learning goal alignment, feedback and adaptation, motivation, presentation design, interaction usability, accessibility, reusability, and standards compliance. LORI evaluations will be coupled with user interviews and surveys that address similar dimensions and also encourage constructive criticism of the product; interview and survey questions must still be developed and submitted for IRB approval prior to product evaluation.

**Assessment of Student Learning (progress to date):** Not applicable at this time. However, with this product, students will be able to perform ‘real’ experiments via distance learning or where equipment/supply resources are limited. Once the model experiment is complete (within a functional software executable file), a wide array of other experiments can be modeled and incorporated. Pre-tests and post-tests for each topical experiment can be developed to measure student learning gains.

**Initial Findings (progress to date):** VirtualUnknown™ is a product that we have recently discovered. This commercially available software shares many of the goals of this project, but simulates only a very specific set of procedures for identifying an unknown bacterial sample. Unfortunately, no published assessments of this product are available to aid in our study, but we will compare its resources, functions, and interface design with ours.

We investigated several stand-alone software packages for developing our learning tool. While Microsoft PowerPoint provides hyperlinking options that would allow the development of a useable interactive ‘software’ for our learning tool, it was cumbersome to program a model such as we designed. We then looked to other software capable of producing interactive animations as well as video gaming software engines (i.e. Quake, SecondLife) for applicability. While the video gaming engines allowed great flexibility and diversity in designing our software, they were very expensive and extremely complicated to program. Instead, Adobe’s Creative Suite 5 Master collection will provide the ability to produce animations, voiceovers, artwork and interactive flash media at a reasonable cost of investment and with less difficulty.