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Assessment of Educational Modules Based on the "How People Learn" Framework Delivered to Biotechnology Learners at Two Universities

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Abstract- **New modular materials and methods for teaching biotechnology have been developed based on the 'How People Learn' (HPL) framework and classroom tested in a STAR Legacy sequence. Domain-specific questions targeting each of the learning objectives were used in a pre/post assessment strategy that seeks to measure the change in learner capabilities. One such pre/post assessment revealed a statistically significant increase in learner performance following intervention using HPL and modular materials. The same pre/post assessment yielded no increase in leaner performance on control learning objectives not addressed in the classroom. Our results suggest that this approach can produce satisfactory interrater correlation and is a sensitive measure of learner performance.**

Keywords **- Educational tools, Challenge-based learning, Biotechnology education**

I. Introduction

The VaNTH (Vanderbilt, Northwestern, University of Texas, and Harvard/MIT) Engineering Research Center (ERC) in Bioengineering Educational Technologies was established by the National Science Foundation to explore the application of contemporary learning theory and technology in the bioengineering classroom. This comprehensive, multidisciplinary and multiinstitutional effort has generated new learning materials and other educational products. The Center is also involved in outreach to industry and K-12 classrooms, among other aims.

Educational modules, primarily based in four domain areas of bioengineering (biomechanics, biooptics, biotechnology and systems physiology), have been developed in this collaborative environment. Classroom testing of these novel approaches is now underway.

New materials and methods for applications in biotechnology have been developed, evaluated, revised and classroom tested. The scientific research of assessing these approaches is described in this work and preliminary results are discussed. Much of the data to be used in the comprehensive assessment will be collected during the Spring 2002 semester and is unavailable at the time of abstract preparation (April 2002), but assessment results from a mammalian cell bioreactor design module (M1) are presented here.

II. Educational Modules

A. Classroom Intervention Methods

Learner activities and the classroom environment were designed to conform to the learning principles described in the recent book by Bransford [1]. Details of this 'How People Learn' (HPL) approach and our specific implementation are described elsewhere [2]. The modular teaching materials are challenge-based and presented in a STAR Legacy sequence [3]. A total of three modules were developed: mammalian cell bioreactor design (M1), momentum transfer in mammalian cell bioreactors (M2) and microbial kinetics (M3). These educational materials were created to address a specific set of learning objectives identified by the domain experts (TDG and GB).

B. Classroom Intervention Schedule

Each module required from three to five 75-minute classroom sessions and included learner activities between sessions. All three modules were used in BME 395 at Northwestern University during the Fall 2001 quarter. Modules M1 and M2 were used in BME 281 at Vanderbilt University during the Spring semesters of 2001 and 2002.

C. Assessment

Assessment of the interventional strategy and the modular educational materials was carried out at both classroom test locations. Quantifying the change in learner achievement on the learning objectives modulated by the intervention is the primary assessment objective. Additional measures were specifically designed to evaluate the modular materials and the course as a whole.

Learner performance on the learning objectives was assessed before and after the classroom interventions. The tools used to conduct this assessment were designed by the coordinated efforts of multidisciplinary teams at both test sites. Domain-specific questions targeted each of the learning objectives on which the modular materials are based. This strategy is a pre/post assessment that seeks to measure the change in learner capabilities on specific topics following an educational experience. Additional pre/post assessment questions were employed for learning objectives that were not the targets of new modular materials and for which HPL classroom interventions were not employed. These non-modular, non-HPL pre/post assessments served as a control for learner performance in the absence of intervention. In this way the relative increase in learner performance in an HPL environment can be compared with non-HPL changes using the same cohort of learners and with the same instructor. In addition, learner comparisons across test sites can also be made, provided that suitable grading rubrics can

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be demonstrated with sufficiently high interrater correlation.

Two control sets of pre/post data were collected at Vanderbilt University during Spring 2002. The learning objectives of module M3 were not included in this course, yielding an evaluation of the pre/post control strategy. A fourth pre/post was conducted in this course based on a molecular biology component that was delivered without the use of VaNTH materials and in the absence of an HPL approach. Control data from Northwestern University is also being collected using a third classroom in which HPL is not used at any time during the course.

D. Preliminary Assessment Results

The assessment question for module M1 was based on a design challenge for a protein production facility using mammalian cell bioreactors. After outlining the global design goals, learners were asked to respond to the following questions:

- Discuss the factors that are involved in the design of a protein production facility. This should include biological issues, modeling issues, and any other technical or practical issues you feel are important.
- Describe a plan for how you would carry out the necessary steps in your design.
- Identify who you would recruit and what resources you would use to help you with this project and why.

Rubrics for scoring learner responses were created based on five learning objectives of the module. Rubrics for two additional learning objectives, not addressed in the module, were also devised as controls. The first module-specific learning objective and the associated scoring rubric follows:

A. Student identifies and discusses biological factors involved in the design.

5. provides a sophisticated discussion of all or most of the biological factors
4. provides a good discussion of most of the biological factors
3. provides an average discussion of some of the biological factors
2. provides a limited discussion of few of the biological factors
1. does not identify any of the important biological factors

Learner response was scored on this and six additional learning objectives, each associated with corresponding scoring rubrics. Two NU raters scored the pre/post responses of 11 learners from the Northwestern University course and produced an interrater correlation of 0.73.

Learner performance on this objective was significantly increased ($p < 0.01$) after HPL instruction, from a pre-intervention score of 2.7 to a post-intervention score of 3.5. Post-intervention performance increased without statistical significance in each of the other four module-specific learning objectives. The two control questions both yielded a decrease in post-intervention score with statistical significance ($p < 0.05$) in one case. Since the pre/post evaluation was time-limited, the decrease in score on non-module objectives is consistent with increased learner focus and time expenditure on the module-specific learning objectives and a relative neglect of the learning objectives not addressed in the module.

Our team is currently working to evaluate interrater correlation across the test sites. VU raters are using the NU rubric to score the Northwestern learner responses. After confirming sufficient interrater correlation among all raters, pre/post data from Vanderbilt University learners will be scored. The comprehensive data set of pre/post evaluations collected from NU and VU learners will then be scored by raters from both test sites using rubrics specific for each learning objective. This strategy will allow comparison of pre/post learner performance under HPL and non-HPL environments. In addition, our experience will serve as the foundation for the dissemination of scoring rubrics associated with learning materials that can be used with confidence at new instructional locations.

III. Summary

Widespread adoption of novel classroom materials and methods depends on unambiguous, persuasive evidence for the superiority of the new approach. We have adopted an assessment strategy that depends on scoring learner performance before and after (pre/post) intervention using well documented, learning objective specific rubrics. Complete results of this experiment will not be available until the conclusion of the Spring 2002 semester, but preliminary evidence suggests that this approach can produce satisfactory interrater correlation and is a sensitive measure of learner performance.

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References

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