Impact of Assessment on a BME Undergraduate Program

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Introduction

Learning theory suggests that effective instruction should be "student centered, knowledge centered, assessment centered, and community centered"[1]. We have been engaged in a large study aimed at exploring and testing these concepts for biomedical engineering education—the NSF Vanderbilt-Northwestern-Texas-Harvard/MIT (VaNTH) Engineering Research Center on Bioengineering Educational Technologies. The set of concepts that have been applied to improve learning have been labeled the "How People Learn (HPL) Framework"[2]. This paper is an overview of our observations on the effects of creating and applying "assessment centered" learning methods in biomedical engineering (BME)—especially the BME undergraduate program.

Assessment and Evaluation

The fundamental ideas of formative assessment (assessment which is aimed at directly improving learning) and summative assessment (which measures accomplishment) are well established in learning theory and practice. A further assessment of interest to the VaNTH project was the assessment and evaluation of the overall impact of learning innovations stemming from VaNTH research[3]. Here summative evaluations of faculty change and student learning were needed to assess the improvements caused by new methods of instruction when compared to appropriate controls. Assessments can be considered to have the following psychological constructs:

- Affective, in which the attitudes, feelings and views of the subjects are measured;
- Behavioral, in which the actions of the subjects are observed;
- Cognitive, in which the concepts, problem-solving abilities and knowledge of the subjects are measured.

We sought and developed methods that would help us evaluate changes resulting from applying the HPL Framework to instruction in biomedical engineering. A diagram of the relationships among these methods is shown in Figure1 and discussed below.

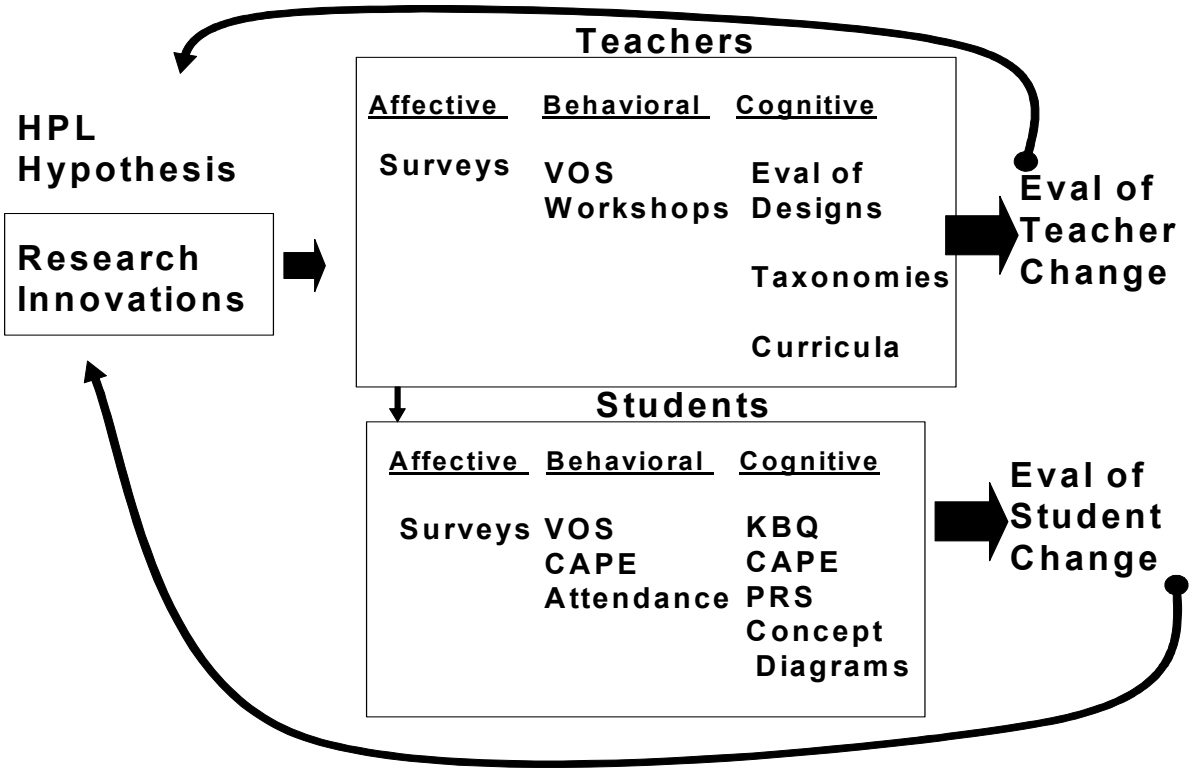

Figure 1: Assessment and Evaluation of Teachers and Students in VaNTH Projects

Assessments of Affective Change

This is a highly-used method that relies on surveys or interviews to determine the attitudes and perceptions of the subjects. We have used surveys to examine the views of students regarding particular courses and have measured changes in HPL content in the courses[3]. This has been extended to teachers' perceptions and has also been used with students to measure their perceptions of the profession of BME and the maturation of their career goals as they move through the curriculum. These surveys have also contained items reflective of desired ABET outcomes. The surveys are also being used to measure the time progress of change in students and faculty as the process of educational reform occurs. The longer new efforts at HPL-based instruction are pursued and expanded throughout the curriculum, the more impact should be seen within the student cohorts replying to this survey. The assessments are "affective" in the sense that they measure student perceptions and opinions. However, comparing these data to other observations (discussed below) could provide additional insight into the effectiveness of teaching innovations.

Assessments of Behavioral Change

We have devised a method for observing classroom interactions called the VaNTH Observation System[4]. This technique involves the presence of an observer in the classroom who codes activities and interactions during the class time on a personal data assistant. This method has shown significant changes in classes where instruction has been redesigned to be challenge-based and informed by HPL principles[5]. While training is required to use this system, it has the attractive feature of being quite objective in observing how instructors and student interact. It records the ways in which teachers interact with students, the ways (positive and negative) in which students are engaged in the classroom and provides narrative notes of the class activities. These observations can be assimilated to provide a global rating of the effectiveness of the observed classroom experience. It provides an excellent measure of active versus passive learning in the classroom. It has served as both an evaluation method (comparison between control classes and classes with teaching innovation) and as a formative assessment method to improve teaching through sharing the results with an instructor.

A number of other behavioral assessments have proven valuable. For teachers, these include attendance at workshops and seminars on methods of improvement. For students, class attendance has been useful. In addition, we devised methods to use web-based homework based on the Courseware Authoring and Packaging Environment (CAPE) of Howard[6]. This system allows instructors to monitor the way in which students approach a set of homework by looking at their use record. This shows the degree of difficulty they may have as well as the thoroughness to which they approach a problem set.

Cognitive

Evaluations of cognitive change in faculty are best observed through an analysis of their instructional design plans. We have devised a template for these designs[7]. These designs can be analyzed for HPL content. In addition, taxonomies of knowledge and curricula are examples of cognitive artifacts from faculty. The most used rubric to analyze curricula has been the ABET outcomes which can be used to assess the content of courses making up curricula.

Student cognitive change has received considerable attention in VaNTH. A primary method has involved the design of key questions (Knowledge Based Questions-KBQ) that can be used in student examinations. We have concentrated on including a few of these in final examinations. The questions have been designed to test students' abilities to integrate the knowledge of the course and are presumed to be a measure of adaptive expertise. Evaluation has been performed by devising rubrics which are applied after regular grades are given by instructors. Additional graders rate the student answers for research purposes. This method has shown significant increases in several aspects of student learning from HPL guided courses[8]. In addition, performances on CAPE generated problems are useful measures of student cognitive progress. Personal response systems (PRS) in class have been especially useful for formative assessment of students. These systems allow students to anonymously respond to questions electronically in class. They usually involve multiple choice questions, and allow the instructor to immediately

see where the class stands on a particular issue. This allows the instructor to emphasize difficult points immediately. Another method of interest is based on asking students to construct concept diagrams. These diagrams are aimed at allowing students to diagram knowledge in a particular domain and show interactions and relationships. Research has shown that experts will produce a highly interactive diagram while novices tend to see few relationships among different concepts. This has been particularly useful in evaluating students' design skills[9].

Overall Impact

The various roles of assessment methods and modes are shown in Figure 1. These techniques have made research on improving BME instruction possible. In addition, the assessment centered designs and activities have had interesting effects on the BME programs in which they have been implemented. Some of these are as follows:

- Devising and using these methods have awakened (or perhaps reawakened) the faculty to the value of formative assessment. Engineering instruction relies heavily on homework problems for formative assessment. In large classes, delays in returning graded homework can limit its effectiveness. In addition, questions in large classes are also limited because of their small coverage and failure to assess the state of knowledge of the entire class. CAPE-based homework that provides immediate feedback and PRS systems can significantly alter the effectiveness of formative feedback in engineering classes.
- Assessment of teachers with observational systems can have a positive effect on improving teaching.
- Surveys are quite useful, but heavy use leads to resistance on the part of students and poor response rates.
- Accurate evaluation can show where improvement efforts can be the most fruitful. Switching from taxonomy –based instruction to challenge –based instruction has provided significant improvements in instruction[8].

ABET review is increasingly concentrated on rationale for curriculum change. Assessments discussed above can provide the basis for rational improvements in curriculum and teaching innovations. Such measures can also provide guidance in the allocations of scarce resources for educational improvement.

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