A Hierarchy Model of Assessment for Curriculum Improvement

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Keywords: assessment, quality of education services (QoES), outcomes, objectives

ABSTRACT

In this paper we present a formal model of assessment to improve the quality of both traditional university curricula and e-Learning programs. The model is useful in addressing the challenges and issues of curriculum improvement in many institutions. We report on our experiences with one of our undergraduate courses, database, taught both in the traditional classroom and via e-learning, offered to students at the College of Staten Island and Shanghai TV University. We also discuss the usefulness of the model in developing formal procedures of assessment which were important for the ABET accreditation of the B.S. degree in computer science at the College of Staten Island.

1. Introduction

Traditional universities have existed for millennia but they still face the need for curriculum improvement [1, 2]. With modern computer and Internet technologies and widely available broadband connections, education through e-Learning has also become a reality [3, 4, 5]. But e-Learning programs are also facing the challenge of improving the quality of education for diverse student populations. This situation has intensified as the result of the globalization of economics with the shift of capital and technologies crossing country borders. A well-trained workforce has become an essential foundation for economic success. As its outcomes improve, e-Learning can play a greater role in providing high quality education at lower cost to the general public, especially, in developing countries, with large populations or large countries with widely dispersed populations, such as Australia, China, India and Russia [6, 7, 8].

Compared with traditional university education, many teaching and assessment methodologies are unique to e-Learning. In many societies, institutions that offer e-Learning programs are viewed as service providers. They provide general education and professional training services to the general public. The student body is widely diversified, from degree seekers studying a complete curriculum to job seekers with specific skill training in mind. E-Learning programs need to provide a wider range of products and services to satisfy the market. One area of difficulty is to assess the quality of the educational provided in the context of the highly diversified and fast-changing objectives imposed by our societies within which the e-Learning programs function.

In this paper we propose a hierarchy model of assessment aimed at improving the quality of education services (QoES) which traditional universities and e-Learning institutions provide. Within the model, we have defined four formal processes with specific functions as well as the interactions between them.

2. The Hierarchy Model of Assessment

Teaching and learning is a dual-process that demands the interactive involvement of both students and teachers. We model this dual-process with four function areas (Fig. 1):

- Objective setting
- Monitoring
- Assessment
- Control

There are two cycles in the hierarchy model of assessment for curriculum improvement:

- Enhancement Cycle
- Adoptive Cycle

The starting point for both cycles is the Objective Setting where a set of measurable teaching or learning objectives is set.

In our case study, objectives are applied to the curriculum as a whole as well as to individual courses. Our B.S. program in Computer Science has identified seven objectives that students of the program must master prior to graduation:

1. Design and implement practical software applications. *e.g.* in the senior software engineering course, students are required to design and code a VB program to let students take and then grade a test.
2. Design and implement hardware components. Using the cadet board students designed a ping-pong game which contains several types of complex circuits and counters.
3. Obtain employment or an internship in the computing field.
4. Write a survey paper. *e.g.* in the senior seminar one of the students researched and wrote about using Virtual Reality (VR) for pain management of burn victims.
5. Give an oral presentation with slides. *e.g.* in the senior seminar each student selects a different current technical topic of interest, researches it, prepares and presents a powerpoint presentation of their topic.
6. Be aware of ethical issues and societal concerns relating to computers in society.
7. Utilize mathematics in solving computer science problems. Laboratory projects might include calculating truth values of quantified statements or determining graph connectivity using a matrix representation of a graph.

Some of these objectives are measured each semester by projects and examinations in individual courses and faculty feedback. Others are measured by a senior exit survey [10] given in the final capstone course and an Alumni survey [10] administered to all alumni of the program every three years.

The enhancement cycle is a micro cycle that begins with monitoring of teaching/learning activity, and which can be utilized whenever monitoring and assessment feedback indicate a need for action. An example is given below.
The next step in this cycle is the assessment of outcomes against the objectives. Assessment results (positive or negative variances) provide guidance for the control of actions which aim to enhance the teaching and learning experiences and to achieve the objectives.

If the assessment results uncover serious problems (possibly indicating a change of trend or environment context change), an adjustment in the objectives may be required. This is effected by starting the adoptive cycle, which is a macro cycle, and is utilized only when major changes are indicated. At an individual level, one example of such an adjustment might be changing outlook and objectives as a person enters a different stage of life and his or her professional career changes. At the societal level, such adjustments might be needed as new technologies and industries are introduced that require a workforce with new skills. For example, the trend of IT and manufacturing migration to India and China, both of which have accelerated recently.

At the College of Staten Island, we have made the adaptive adjustment of reassigning a course to another professor, when assessment results have shown that learning outcomes differed substantially with different teachers.

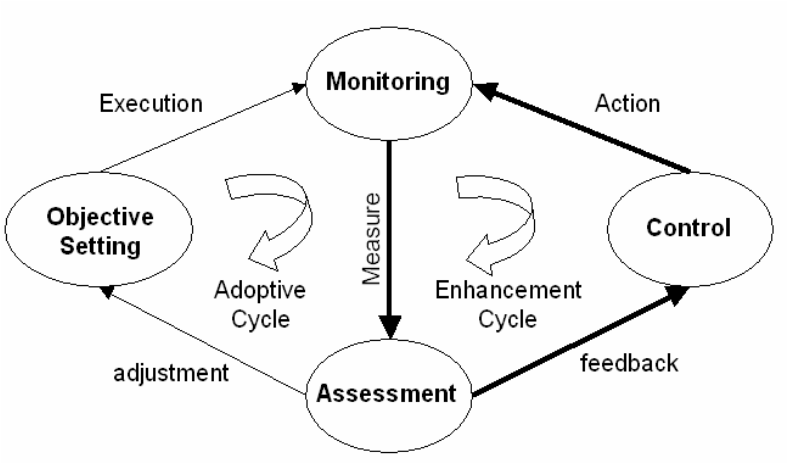

Fig. 1 A teaching and learning process model

The model can be applied at all levels in a teaching/learning institution: an individual student/teacher, a single curriculum, a degree program, a department, a university and the society within which it operates. Hence we call it a hierarchy model where the modeling of processes applies at each level. Through assessment, the lower levels provide feedback at the same level and, more importantly, to a higher level where critical strategic decisions are made.

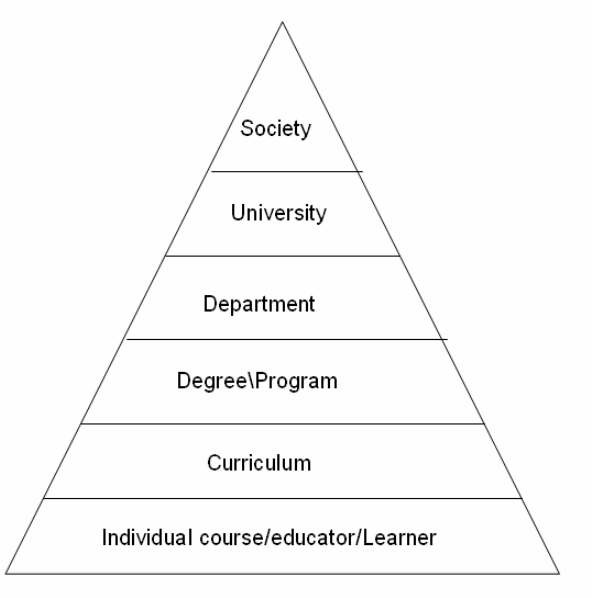

Fig. 2 A Multi-level Hierarchy Model

Assessment is a critical and integral part of this process at every level. We have examined the importance and impact of assessment for enhancing the teaching/learning experience, and performance at the individual and institutional levels within the framework of the above model. Students and teachers play dominant roles of learner and educator respectively. But their roles also interact. Educators and learners may assess each other simultaneously. Their assessment results may lead them to different control of actions or adjustment of their objectives. This is an interesting phenomenon. Students are continually evaluating the teaching, learning, curriculum and resources used in the curriculum. Goals and standards must be clearly specified so that students understand what they are expected to learn. Methods of measuring student achievement should be specified so that students know how they are expected to demonstrate their learning.

Commonly, in a higher education setting students speak among themselves about how they experienced a course and based on the aggregation of "what is heard" make course, teacher and curriculum decisions. This informal feedback loop must be formalized if we are to successfully improve outcomes.

3. Case Studies

In 2005, the College of Staten Island B.S. degree computer science was re-accredited by ABET (the Accreditation Board for Engineering Technologies). We report here on our experience with ABET accreditation standards and procedures [9], and how they are reflected in the hierarchy assessment model for curriculum improvement.

Case Study 1: Bottom level of the hierarchy - The database course

One of the authors has developed and taught an undergraduate Database course [11], in which the set of learning objectives includes:

- Understand relational database theory
- Learn the normal forms of relations
- Apply knowledge of normal forms to database design

- Ability to use the SQL language to write complex queries to a database

In this course, we monitor the teaching/learning activity by

- Exams which test knowledge of the theory
- Design projects which are very carefully evaluated to measure the quality of the student's designs
- Retrieval projects which measure the student's ability to write complex query programs in SQL
- Questionnaires which ask the student to evaluate their learning experience

As an example of the enhancement cycle, one of the authors, who designed and teaches this course, has found that certain theoretical concepts, *e.g.* 2NF or Second Normal Form, are particularly difficult for many students to understand well enough to utilize in designing their own databases. We have redesigned this topic to include more explicit examples. An assignment has been developed which presents the student with a database in which one of the tables violates 2NF. The student is asked to critique and improve the design.

Case Study 2: Second level of the hierarchy - The B.S. curriculum [12]:

The College of Staten Island B.S. degree in Computer Science has been accredited since 1989. After the October 2003 accreditation visit from ABET we formalized our assessment process. In addition to alumni and senior exit surveys, we added faculty and student surveys for each course in our major. We formed an Outcomes Assessment Committee (OAC) to review the completed surveys [13]. The OAC meets after each semester, reviews the surveys and makes recommendations for program improvement.

As a result of this process, we identified several issues to address. The formal outcomes assessment procedure revealed:

Faculty Feedback:

- Identified a weakness in our students' programming skills
- The Discrete Mathematics course included too many subjects (programming and mathematical concepts)
- Writing skills of our majors needed improvement

Student Feedback:

- Requested more electives
- Requested courses dealing with Internet technology

Based on OAC recommendations, the department curriculum committee suggested significant changes in our program to the department. The department approved several curriculum changes[14].

Program Improvements:

- Introduced a new required course, Intermediate Programming
- Removed new programming concepts from the Discrete Mathematics course
- Made Intermediate Programming a prerequisite to the Discrete Math course
- Introduced new programming concepts in the Introductory Programming course, *e.g.* GUI assignment and an introduction to robotics
- Increased the number of required electives from two to three
- Regularized a "special topics" course in Internet Technology
- Required the writing of a User Manual for all large programming assignments

In accordance with our multi-level hierarchy model shown in Fig. 2, the first adjustment is at a single course level and the second adjustment is at the curriculum level via the feedback from the lower level. In our current undergraduate program at CSI, we are offering the intermediate programming course for the first time in the Spring 2006 semester. The impact assessment results will be evaluated during the Fall of 2006.

4. Summary:

Assessment and quality control are critical and challenging problems for many traditional and e-Learning programs. Without defining formal processes it is extremely difficult to conduct sufficient assessments to control the quality and improve curricula to best achieve the objective of providing open, affordable and quality education for all of our students. In our experiment, the hierarchy assessment is instrumental in providing us with guidelines and processes in a full assessment cycle to integrate, monitor and control actions across different levels, from individual course to curriculum. As more traditional and e-Learning courses are introduced to our programs, we are planning to go through multi-phase assessment data collection and analysis to further test and validate the model. Improvement of educational outcomes is, of course, the ultimate goal of this work. Both cycles of the teaching/learning process model and the multi-level hierarchy model are tools which we suggest to assist in achieving this goal

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