Section 1323

Becoming TC2K Compliant: Implementing Outcomes Based Assessment to Improve Engineering Technology Course Delivery

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ABSTRACT

The shift in the accreditation process in both engineering and engineering technology from traditional instructional models to curricula centered on outcomes based assessment presents a challenge to department chairman and program coordinators to meet the requirement of these new criteria. Similarly, this new criteria presents an interesting challenge and opportunity to teaching faculty to both meet this challenge as well as to improve the delivery of their course materials.

The successful shift to outcomes based assessment will require teaching faculty to reassess the manner in which the approach to the preparation of course materials will center on the instructor to identifying what skills, techniques and knowledge will be developed by the student during each individual course. The challenge for the instructor is then to develop methods to demonstrate that these skills, techniques and knowledge have been successfully transmitted to the student.

Implicitly, this is what has been done in the past but without a specific measure of the skills, techniques and knowledge to developed in each course. Therefore, the shift to this new assessment technique is not really that great but requires a shift in focus in the instructor's thought process of course delivery as well as developing the tools to assess the learning style of the students as well as the effectiveness of the course delivery.

This paper will present examples of techniques to convert existing materials to the outcomes based assessment approach as well as suggest techniques to measure the delivery of these materials in both course imbedded techniques as well as techniques to assess course-established objectives and outcomes.

TC2K ? Certainly it's an interesting acronym. The Technology Curriculum for the 21st century (TC2K) represents a departure from the manner in which the evaluation and accreditation of engineering technology programs will be performed in the very near future. This departure represents a shift from the program-based method of evaluation to an outcomes based assessment method. This shift will not mean a complete change in program criteria. Rather, it is a shift in the manner in which assessment will occur and parallels the change in program criteria mandated by ABET for engineering programs under EC2000.

Traditionally the manner in which the Accreditation Board for Engineering and Technology (ABET) prescribed curriculum was program based. By that it is meant that the criteria for a program was specifically enumerated as part of ABET's criteria for a program. The main focus of doing program evaluation therefore became one of an evaluator reviewing the materials presented to him during an accreditation visit and basically seeing that all course areas were included. The next step for the evaluator was then to judge whether or not the materials presented were academically appropriate for the course level. Included in the process, as a general requirement was a requirement for strategic planning, program outcomes and assessment. However, while this material was reviewed and cited, the bulk of the work of evaluation was done in the course material.

Two problems are readily apparent from the "old" criteria. Initially, there was no clear division of responsibility for course materials between upper division (3rd and 4th year) and lower division (1st and 2nd Year) courses resulting in an overlap of course material between these two types of programs. Secondly, there was no clear definition of course expectations of level of complexity between upper and lower division course work. Thirdly, the "old" criteria allowed for a static program, that is, a program that does not change in response to student needs or respond to changing technology. Lastly, and most importantly, it did not provide a standard by which anyone could measure the effectiveness of the delivery of the program. There was no real emphasis on an assessment of the outcome of the education offered. Basically all national programs should essentially resemble one another regardless of geography.

TC2K attempts to address these problems. While it is recognized that it is possible for there to be an overlap of materials between upper and lower division course materials, there is now to be a differentiation made in the course expectation between these two types of programs in the level of knowledge that is to be expected in each of these programs. The shift to outcomes assessment will mandate that a program look at both internal and external factors in the delivery of their program. By this it is meant that internal review will focus on the academic needs of the student as a function of course delivery and other factors relating to delivery of course materials. External review should include such areas as the market into which program graduate are moving, that is, what does industry want?

As an example, the current ABET criteria for the 2002-2003 breaks the accreditation process into criteria, a conventional criteria and the TC2K criteria.

The conventional criteria[1] for Construction Engineering Technology reads as follows:

II.H.2.b. Technical Specialties

II.H.2.b.(1). Associate degree curricula must include topics in contract and specifications, construction materials, construction methods, cost estimating , elementary structures, engineering graphics, material testing and surveying.

II.H.2.b.(1). Baccalaureate degree curricula must include topics in contract and specifications, construction materials, construction methods, cost estimating , concrete, steel and wood, engineering economics, engineering graphics, material testing, plane surveying , scheduling, and soils and foundations and earth structures.

The TC2K criteria[2] for this same curriculum reads as follows:

Objective

An accreditable program in Construction Engineering Technology will prepare graduates with the technical skills necessary to enter careers in construction, operation and/or maintenance of the built environment and global infrastructure. Graduates of associate degree programs will typically have strengths in the building, testing operation and maintenance of buildings and infrastructure with the ability to utilize basic construction documents to participate in construction activities, whereas baccalaureate degree graduates are prepared to specify project methods and materials, perform cost estimates and analyses and manage construction activities.

Outcomes

Associate degree programs must demonstrate that graduates are capable of

a. Utilizing modern instruments, methods and techniques to implement construction contracts, document, and codes;
b. Evaluating materials and methods for construction projects;
c. Utilizing modern surveying methods for construction layout;
d. Determining forces and stresses in elementary structural systems;
e. Estimating material quantities and costs, and;
f. Employing productivity software to solve technical problems.

Baccalaureate degree programs must demonstrate that graduates, in addition to the competencies above, are capable of:

a. Producing and utilizing design, construction and operations documents;
b. Performing economic analyses and cost estimates related to design, construction and maintenance of systems in the construction technical specialties.
c. Selecting appropriate construction materials and practices.
d. Applying principles of construction law and ethics;

e. Applying basic technical concepts to the solution of construction problems involving hydraulics and hydrology, geotechnics, structures, construction scheduling and management, and construction safety; and
f. Performing standard analysis and design in at least one recognized technical specialty within construction engineering technology that is appropriate to the goals of the program.

As can be seen from the above, the new criteria will clearly distinguish between Associate and Baccalaureate degree programs. This is seen in the language attached to each of these criteria as to the outcomes expected of the graduate of each of these two programs.

While ABET has prescribed the objectives and outcomes, it has not prescribed the method or manner in which these objectives and outcomes are to be achieved. Nor is it prescribed how the evaluator will determine whether or not these objectives and outcomes have been met. The assessment of the stated objectives and outcomes must be measurable, however, there is no standard vehicle to demonstrate that these objectives and outcomes. This will require a few basic changes.

Again, using the above sample criteria, it should be noted that the subject matter has not really changed between the two criteria. Rather the change is in the expression of the goals and expectations of the knowledge of material and the requirement to determine if these goals and expectations have been successfully met.

Bloom[3] suggests that learning can be reduced to a two dimensional framework of cognitive processes and knowledge. The cognitive process can be broken down into six aspects:

1. Remember - retrieve relevant knowledge from long-term memory
2. Understand - Construct meaning from instructional messages, including oral, written and graphic communication.
3. Apply - Carry out or use a procedure in a given situation
4. Analyze - Break material into constituent parts and determine how parts relate to one another and to an overall structure or purpose.
5. Evaluate - Make judgements based on criteria and understanding.
6. Create - Put elements together to form a coherent or functional whole; recognize elements into a new pattern or structure.

The knowledge dimension can be further broken down into four areas:

1. Factual knowledge - The basic element students must know to be acquainted with a discipline or solve problems.
2. Conceptual knowledge - The interrelationships among the basic elements within a larger structure that enables them to function together
3. Procedural knowledge - How to do something, methods of inquiry and criteria for using skills, algorithms, techniques and methods.

4. Metacognitive knowledge - Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.

Based on the foregoing as a structure, it can be assumed that the requirements for the Associate degree programs would lie in the first few aspects of the cognitive aspects while Baccalaureate programs would fall into the latter aspects of the cognitive processes.

One distinct problem that has occurred with the existing criteria was that of course overlap, particularly with ET programs that are "plus two" programs. A "plus 2 program is one where the students receive their Associate degree program at one school and enter a Baccalaureate program at another institution for the final two years of their program. Using the model shown above, that of the Construction Engineering Technology program, it is noted that several subject areas are repeated in both the Associate and Baccalaureate programs, leading to an overlap of materials. Under the TC2K criteria, subject materiel is still repeated but the breadth and depth of the knowledge within each program is specifically identified.

Therefore, in order to address and demonstrate that the competencies requested have been achieved, it will be necessary to prepare a strategic plan for each program establishing where the program objectives and outcomes will be reached.

The strategic planning for a program under the prior criteria was fairly simple. One could basically take the listed criteria, name a course after each stated criteria and be within the bounds of the criteria. However, the only determination required by the evaluator was to do a form of "bean counting" by matching the criteria to the course and then determining, in the evaluator's opinion, if the course material was of an appropriate level. There was no discussion or review of the success of the course delivery.

The TC2K criterion requires a more extensive strategic plan for course delivery. While the new criterion does establish identifiable, assessable skills and knowledge, it does not require specific courses to accomplish those tasks. Rather it requires that a program coordinator establish a plan to achieve these results over the breadth of the program. This certainly gives a greater degree of latitude to achieve the overall goal of the program as well as requiring a demonstration that these goals have been successfully delivered by requiring assessment of the outcome of the program. This certainly empowers the individual instructors to review their process of course delivery and modify the course delivery to improve the success of the students within the program.

One possible area do conflict would be in the implementation of multiple sections of a course taught by different instructors. While academic freedom could become a problem, the clear identification in the strategic plan of core materials and skills that need to be delivered and assessed should resolve this situation. In fact, in the assessment of multiple sections might lie some discovery of the most effective teaching techniques for particular material and may facilitate the overall improvement of teaching techniques among colleagues.

The preparation of course outlines and syllabi represent another area where TC2K will require some changes to course planning and administration. In many course outlines and syllabi speak

in very general terms for course coverage and expectations. While this approach may be sufficient for existing criteria by stating course goals in very broad, general terms, it fails to identify specific measurable skills, techniques or knowledge that will be gained by the student as part of the learning experience for a particular course. For example, the course goals and objectives for a basic strength of materials course might consist of a general description as follows

> " The objectives of this course will consist of the stress and deformation in a wide range of simple practical structural problems and an understanding of the mechanical behavior of materials under various conditions..."

While this general description may be acceptable under existing accreditation criteria, allowing the program evaluator the freedom to determine if the materials reviewed during the accreditation process meet these general criteria, The TC2K criteria requires a more specific approach to course material delivery. Accordingly the above description can be easily modified to specify to comply with TC2K criteria by establishing specific course goals and objectives for this same course in the following manner

> "The objectives of this course will consist of the following:
> 1. The student will develop knowledge of the stress and deformation of simple beams and be able to analyze a beam in bending, axial loading and in torsion.
> 2. The student will be able to analyze an indeterminate beam in bending and in axial loading conditions and determine the deformation of the beam under these loading conditions."

As can be seen by this example, the modification of these course goals and objectives switched from general language to more specific, identifiable and assessable language.

The impact of this change is two-fold. First, for TC2K it identifies the specific skills to the program evaluator that will be learned and assessed for this course. Secondly, and probably most importantly, it identifies for the student what the instructor's course expectations are and how the student's course performance will be evaluated by the instructor.

A collateral issue may arise with multiple sections of the same course being taught by different instructors. The implementation of the course's strategic plan, as discussed above, would allow for identification of common skills and knowledge between multiple sections without interfering with the academic freedom of the individual instructor.

In conjunction with that strategic plan, course outlines and syllabi, highlighting the specific outcomes that will achieved within each course should be prepared. For the most part this will not necessarily require the preparation of an entire new set of course outlines and syllabi, rather is will require modification of existing materials to reflect the program objective and outcomes.

This may require the instructor to rethink the course materials to stay true to the course objectives and demonstrate the attainment of the course outcomes through testing. However, it

may also be necessary to benchmark competencies at the beginning and end of the course to further buttress the stated outcomes.

Probably the most direct way to establish objectives and assess outcomes is via the course outline and the actual testing that will be conducted during the course. In fact, the course outline may serve as the structure for the final examination for the course. This serves two purposes. It provides an outcomes assessment vehicle as well as providing the student with a study guide for the course starting with the first day the student is handed the course outline.

The change to TC2K is not immediate. Rather, this process will occur over the next few years. However, with all the advance work that will be necessary, such as the creation of a strategic plan and the modifications to course materials that are required to fully implement this type of criteria, it is important to begin the process as soon as possible.

Footnotes

[1] "Criteria for Accrediting Engineering Technology Programs, 2001-2002 Cycle, Section G-III-4b", ABET
[2] "Criteria for Accrediting Engineering Technology Programs, 2001-2002 Cycle, Section L-VI-2c", ABET
[3] A Taxonomy for Learning, Teaching and Assessing, A Revision of Bloom's Taxonomy of Educational Objectives

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