Best Assessment Practice

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Introduction

The new ABET Criteria for engineering programs have been mandatory for all engineering programs for several years now. Programs are being revisited for the second and third time and "full" compliance with the Criteria is now expected. The ABET Criteria for Applied Science and for Engineering Technology have an assessment and improvement requirement very similar to the engineering requirement and the Computer Accreditation Commission has similar requirements for computer and information science programs.[1] It is time to begin to agree on what constitutes best assessment practice.

Although it is often said that engineering programs are out in front on assessment there is a great deal being done at all levels of education. And, as most faculty members would agree, there is no need to reinvent the wheel with assessment. However, there is the need to have a sustainable assessment and evaluation system in place that serves institutional and program needs and ensures that the program satisfies the ABET Criteria.

The Joint Committee on Standards for Educational Evaluation (JCSEE) is an American National Standards Institute (ANSI) accredited standards developer and has recently (2003) published “The Student Evaluation Standards” as an American National Standard (ANS).[2] The introductory materials that are not part of the standard state that in testing the standard, most of the field testers were "actual classroom teachers who applied the standards to improve their own student evaluation practices." In discussing how to apply the standard, the joint committee suggests that it is not necessary to apply all of the standards but that it is necessary to "begin applying them to your thinking about student evaluations."

The paper describes a preliminary application of this standard to the evaluation of a course in foundation engineering at the Catholic University of America. The course is not a required course for all students and it is not the required capstone course. However, senior design-intensive courses are excellent courses to focus on for assessment and thus this is a reasonable test of the applicability of the standard to evaluation of engineering students.

Foundation engineering course

This course is a traditional foundation engineering course with the prerequisites of theory of structures and soil mechanics both three-credit third-year courses. The first course in soil mechanics is currently lecture only. There is a required soil mechanics testing course

(two credits) that all students are required to take but it is not a prerequisite for foundation engineering.

The overall objective of the course is to prepare students for the professional practice of geotechnical engineering and in this way contribute to the overall goals of the program. The current educational objectives for the course are: to gain proficiency in the geotechnical design of shallow and deep foundations and earth retaining structures, using bearing capacity, settlement, and earth pressures theories and structural and performance design criteria; to learn site characterization procedures including sampling and *in situ* testing to determine design parameters.

The current expected course outcomes are:

- Ability to apply engineering science principles, including shear strength, compressibility and earth pressure to predict the behavior of shallow and deep foundations and earth retaining structures.
- Ability to develop and use spreadsheets for basic foundation design calculations.
- Ability to plan a site investigation program, including sampling and *in situ* testing, to characterize a site and to determine design parameters.
- Ability to write a professional, geotechnical engineering report and to make an oral presentation to a "client."
- Ability to work in a group to develop and design an engineering solution, write a report, and make an oral presentation.

Current assessment involves the following processes:

1. Two hour long exams and a final exam to provide feedback on the comprehension and application of geotechnical design principles. The first exam covers the basics of soil mechanics and students are expected to demonstrate knowledge at the level of the discipline-specific FE/EIT exam. The exam is closed book and students use the equation sheet provided for the FE/EIT exam.
2. The second exam and the final exam are modeled after the PE Breadth/Depth exam in civil engineering with the depth being in geotechnical engineering. Students are expected to demonstrate knowledge of the application of fundamentals in geotechnical design and a basic proficiency in geotechnical engineering equivalent to that currently required to pass the PE exam. The second exam and the final exam are open book; students are allowed to use the text book but no other resources.
3. Homework problems sets are assigned generally one per week due the following week and are graded and returned to students.
4. A project to provide a measure of students' ability to apply technical material to the solution of a real-life problem in a group setting.
5. For communications there are assignments posted on the web; a field trip report; and a detailed, written report and oral presentation summarizing the project.
6. The university course evaluations provide student feedback on the perceived quality of the course and the effectiveness of the instructor.

The estimated ABET content for the course is 100% engineering topics (Engineering Science 33%, Engineering Design 67%)

The following ABET outcomes are currently considered by the instructor to be addressed: (a) an ability to apply knowledge of mathematics, science, and engineering (c) an ability to design a system, component, or process to meet desired needs (e) an ability to identify, formulate, and solve engineering problems (f) an understanding of professional and ethical responsibility (g) an ability to communicate effectively (i) a recognition of the need for, and an ability to engage in life-long learning (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.[3]

The grading systems follows the university letter-grade system which allows for + and – letter grades with < 60 % constituting failure.

Previous improvement efforts

The textbook was changed to Das[4] from Coduto[5]. The rationale was that Coduto's book includes extensive applications to structural design of foundations that was not included in the current syllabus. Das's text has very little structural design and is more suitable for the course as it is currently offered. Students are required take concrete design but may not have had it prior to taking foundation engineering and are not required to take it in parallel. One downside of this is that students may not be exposed to the structural design of foundation elements which is covered on the current PE exam. However, between the two courses, they should be prepared to learn this on their own by the time they are eligible to take the PE exam. I stress in the course that students should be well prepared to take the PE exam in the geotechnical area. To support this, I use the geotechnical depth/breadth exam as guidance for updating the syllabus.[6]

A comprehensive design project was dropped in favor of a comprehensive project. The course had been taught twice before with a comprehensive design project based on the field trip. However the logistics of getting the field trip and supporting materials to the students in a timely fashion had been a problem. With the increased scope of Criterion 3 (c), the outcome for design will be removed as one of the outcomes for the course. The course is design intensive and ensures satisfaction of proficiency in a major area of civil engineering but is not comprehensive enough to address the range of constraints now called for in Criterion 3(c).[7]

The course emphasizes the use of spreadsheets to automate design calculations. One downside of Das's book is that it does not integrate spreadsheets into the text as Coduto does. The spreadsheets in Coduto's text can be freely downloaded from the textbook site and are suggested to students as starting points for their spreadsheets.[8] Although the students take a required programming course in computer science, the language is not currently specified and this group of students (fall 20040 had apparently had a class in JAVA. The required first course for computer science students is JAVA so this is not too surprising. Civil engineering students use MATLAB™ as part of their required

differential equations course which is taught by engineering faculty. However, students last fall (2004) had had limited experience in using spreadsheets and could not at the start of the course incorporate macros into their spreadsheet solutions. Although macros are not used in Coduto's spreadsheets, the use of macros adds enormous flexibility to spreadsheets and some use of macros is probably necessary if students are going to be able to develop their own design solutions.

Planned improvements

Plans are to modify the topical coverage slightly to maximize the coverage of material currently on the geotechnical bread/depth PE exam. My thinking is that students will have been exposed to the material once and thus will be more likely to follow up and take the PE exam when the are eligible. It is suggested to students that this is "life-long-learning" challenge and they should be prepared to learn some foundation engineering on their own.

As indicated above, I will also remove Criterion 3(c) as an expected outcome for the course. I also plan to increase the use of spreadsheets in the course.

Selection of student evaluation standards to apply

The CUA School of Engineering is developing a standard process for course evaluation and review and the author decided to see if the JCSSE student evaluation standards might provide some useful guidance.

The Student Evaluation Standards (SES) consist of 28 separate standards broken down into four categories: propriety, utility, feasibility, and accuracy. For the purposes of this example I will focus on utility. According to the SES, "The utility standards help ensure that student evaluations are useful. Useful students evaluations are informative, timely, and influential." The utility standard is broken down further into seven standards that cover issues such as who will use the data (U2); e.g. the individual faculty member, a faculty committee, or the ABET evaluator. There is a standard U3 that deals with information scope; e.g. are we collecting the information that will allow us to evaluate achievement of course outcomes and ABET outcomes? Standard U7 deals with follow up; e.g. is the information being used to modify the course so that the course provides appropriate preparation for entry into practice here as specified in the current FE and PE specifications

The format of the standard includes a definition of the standard; an overview; guidelines; common errors in applying the standard; one or more illustrative cases; and selected references. None of the illustrative cases deal with engineering courses although a number of them deal with university-level education and several with professional- level education primarily health care.

The course being evaluated is a civil engineering course so the primary users of the data will be the instructor and the students, civil engineering faculty members, and, at each

ABET review, potentially the ABET civil engineering evaluator. ABET guidance in the current Self -Study Questionnaire sees outcome assessment an internal process with faculty members having the primary role with students playing an integral role.[9] Other potential users include the department advisory committee and other groups interested in the improvement of the civil engineering program.

The U2 standard also requires that the uses of the student evaluation be specified so that "evaluation contributes to students learning and development." This is in fact the vision of the new ABET criteria which is being evaluated in a current study being done by the Penn State University Center for Higher Education.[10] In this course, the evaluation data is being used first to improve student learning and in this way improve teaching but also to meet the specific assessment and outcomes requirements for ABET.

The course as currently organized assumes a prerequisite level of knowledge equivalent to the FE civil engineering specialty exam. The School has recently adopted a policy that all students will be required to take the FE exam effective with the graduating class of 2006 and students are being informed of this. In theory, students could be given a FE-level soils exam at the first class meeting in foundation engineering. Rather what is being done is to do this with the first hour exam that also includes some review and elaboration of material in the first soil mechanics course e.g. the application of consolidation theory and some new material on codes and standards. Since not all of the students may have had the soil testing course, some additional time is also taken to relate basic theory to soil testing and to site investigation and design. Although over reliance on grading for assessment can be an issue, in this course, less than 60% on the first exam strongly suggests that the student was not prepared for this course and will not meet the overall goal of the program and that some remediation is in order. I believe that this case can be made for any course designed to meet the civil engineering program criteria for proficiency in a major civil engineering area.

The classes at CUA are too small to make statistically meaningful judgments from test results but one action suggested by this review is to review first exam results with the instructor of the soil mechanics course and agree on steps to improve students' readiness for foundation engineering. I design the first exam to ensure minimal coverage of the areas specified in the FE exam related to foundation engineering but it does not include all areas covered in the soil mechanics course.[11]

My concept is that performance in the first course demonstrates readiness to enter the field of civil engineering - an overall program goal. This is evidenced by course materials from the first course and demonstration of satisfaction of the prerequisites for the second course in this case by the first hour exam. Remediation is possible since additional testing and problem solving opportunities are possible in the second course. The foundation engineering course is taught using WebCT and the testing component could be used to generate additional test data. I encourage students to post all work on the web which provides me with an electronic portfolio for each student. I have not made much use of the self-testing options yet because they are so labor intensive.

Arlen Gullickson reviewed a draft of this paper and suggested I develop an instrument, preferably online, for assessing "fundamentals-level" knowledge of geotechnical engineering.[12] This instrument would not be graded and would only be used for assessment and improvement of learning. I plan to start this in the fall possibly using the WebCT testing component.

I consider that performance in the foundation engineering course demonstrates proficiency in one of the four areas of civil engineering as required by the civil engineering program criteria.[13] Here a passing grade represents minimum proficiency.

This brief example suggests that careful study of the SES standards in the context of courses that a faculty member is teaching can yield useful qualitative results. This example also highlights the important point that most courses do not exist in isolation and that program improvement requires a coordinated evaluation effort.

Conclusions

The American National Standard (ANS) on student evaluation has been reviewed with an example to illustrate how it might be used to guide assessment and evaluation processes in engineering programs. Does this standard constitute best practice for student evaluation and assessment? Engineering standards are normally expected to encapsulate good if not best practice and although these standards developed have been developed primarily by the education community, the warrant careful consideration and study by faculty members and programs seeking to avoid reinventing the assessment wheel and still have a strong evaluation process to support accreditation.

The JCSEE has a second standard on program evaluation that may also be useful to engineering and engineering-related programs. This standard was but is not currently an ANSI standard but it is being updated – currently in its 2nd edition – and will be submitted for approval as an American National Standard in the near future.

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William E. Kelly joined the Catholic University of America in 1996 from the University of Nebraska - Lincoln. He holds, BS, MS and Ph.D. degrees from the University of Notre Dame. He is a past chair of the ABET EAC, a member of the ANSI Board of Directors, and currently chairs the ANSI Committee on Education.

End Notes

[1] ABET Criteria for Accreditation of Engineering, Technology, Applied Science programs all at http://www.abet.org/criteria.html

[2] Joint Committee on Standards for Educational Evaluation A.R.Gullickson, Chair, 2003 The Student Evaluation Standards: How to Improve Evaluations of Students, Corwin Press, 240 pp.

[3] These are in Criterion 3 of the current 2004-2005 criteria http://www.abet.org/criteria.html

[4] Das, Braja M. Principles of Foundation Engineering, Brooks Cole, Fifth Edition.
[5] Coduto, D.P. 2001 Foundation Design: Principles and Practices, Prentice Hall, Upper Saddle River, NJ, Second Edition.
[6] NCEES Specification for geotechnical depth and breadth.
http://www.ncees.org/exams/professional/pe_civil_geotechnical_exam_specs.pdf
[7] Criterion 3 (c) The old criterion was an "an ability do design a system, component, or process to meet desired needs" and the new Criterion 3(c) now adds "within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability"
[8] Coduto spreadsheets http://cwx.prenhall.com/bookbind/pubbooks/coduto/chapter0/deluxe.html
[9] EAC ABET Self-Study Questionnaire says "Outcomes assessment is largely an internal activity for which the criteria do not require the participation of external constituencies. The EAC expects the faculty to have the primary role in the assessment of program outcomes and for the internal constituencies, particularly the students, to play an integral role." See EAC Self-Study Questionnaire http://www.abet.org/info_prgs.html
[10] Penn State Center for the Study of Higher Education http://www.ed.psu.edu/news/abet.asp
[11] NCEES specifications for Fundamentals exam
http://www.ncees.org/exams/fundamentals/fe_exam_specs.pdf
[12] Gullickson, A. R. personal communication to W.E. Kelly January 30, 2005
[13] Civil Engineering program criteria See 2005-2006 Engineering Criteria
http://www.abet.org/criteria.html