Towards Standardization of ABET Student Outcome Assessment

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Abstract

The design and development of a relational database for standardizing ABET Student Outcome assessment is presented in this paper. The design process, from problem definition through detailed design, is followed and documented. The functionality developed includes a course-wise repository for Student Outcome assessment instruments; ability to add and delete courses; the ability to add, edit and delete Student Outcomes; and, the ability to add 'Instructor Notes' to specific Student Outcomes/courses. The system is designed to be adaptable to changes in Student Outcomes. This is advantageous since ABET is expected to update its Student Outcomes in the near future. A detailed relational schema is presented in this paper, and is made available online for use by fellow academicians. The assessment instrument repository, the note keeping functionality, and the other design features are intended to ensure that ABET Outcome assessment methods are independent of individual instructor biases, are continuously improving, and become standardized over time.

Keywords

ABET; Student Outcome Assessment; Data Management; RDBMS;

Frame of Reference

Accreditation Board for Engineering and Technology
The Accreditation Board for Engineering and Technology (ABET) was originally founded in 1932 as the Engineer's Council for Professional Development. Since then it has served as the leading accreditation body in the US for undergraduate programs in Engineering and Technology and recognized as an accreditor by the Council for Higher Education Accreditation. ABET's emphasis on program accreditation follows specific criteria. For engineering programs, the Engineering Criteria adopted in 2000 (EC2000) focuses on outcomes of the program, rather than the delivery of the program. Currently, ABET has accredited approximately 3,700 programs in over 750 colleges and universities across 30 different countries[1].

ABET's Engineering Accreditation Commission (EAC) is in charge of accrediting engineering programs. The criteria used by the EAC consist of general criteria and program criteria, which is specific to certain programs. The intention of such criteria is "to assure quality and to foster the systematic pursuit of improvement in the quality of engineering education that satisfies the needs of constituencies in a dynamic and competitive environment"[2]. One of the most important criteria evaluated by the EAC is the Student Outcomes (SOs). The Student Outcomes describe skills and knowledge that students are expected to possess by the time of graduation. In addition, the SOs should also prepare students to attain the Program Educational Objectives (PEO's). The SOs are defined by each institution, though ABET requires eleven outcomes that all programs must include

in some way. Each program must demonstrate and document the attainment of the SOs by developing and implementing an assessment process that should measure all outcomes and compare to a certain level. The results of such assessments, which are recommended to be performed regularly, should be the basis of a program's continuous improvement.

Current State of Student Outcome Assessment

The student outcome assessment process should aim to collect meaningful data that will help a program determine if students have attained the student outcomes, as compared to a specific level defined by the program. ABET suggests that assessment should focus on the learning of the students and not the assessment or evaluation of individual courses, as this is a measure that provides insight on the program's ability to achieve what it intends[3].

Results of assessments should be used as evidence that the SOs are attained, and to identify opportunities for improvement of the program's teaching strategies, learning methods, and assessment policies. Traditionally, assessment occurs at a frequency determined by individual programs. Delivery methods and assessment instruments used also vary by institution and by program, as this is often defined by the faculty members delivering the courses in which outcomes will be measured. A wide variety of assessment instruments have been used historically and typically include (but are not limited to): specific exam questions/problems, rubrics, peer evaluations, faculty evaluations, isolated assessment, or any combination of these. While there is no specific rule or standard for the way in which student outcome assessment is –or should be– conducted, ABET does offer suggestions of successful assessment practices and strategies through a selection of workshops or seminars offered throughout the year[4].

Need for Standardized Assessment

When ABET overhauled their accreditation criteria in 1997[5] by adopting Engineering Criteria 2000 (EC2000), the objective was to increase flexibility and "empower innovation," while maintaining rigor and focusing on student outcomes. Among other things, this flexibility affords programs the freedom to map student outcomes to courses within their curriculum, and it affords the use of several different assessment instruments. While this freedom and flexibility is in accordance with EC2000, it allows for variability of SO assessment: (a) within a program; (b) across programs within an institution; (c) and, across programs and institutions.

The need for consistent SO assessment within a program is understandable. It is desirable for assessment performed in a course, across semesters, to be independent of instructor biases. For example, Professor X teaches Introduction to Industrial Engineering in Fall 2016, and Professor Y teaches the same course in Fall 2017. Ideally, SO assessment performed in Introduction to Industrial Engineering in Fall 2016 should be consistent with the assessment performed in Fall 2017. In other words, the individual biases of Professor X and/or Professor Y should not affect student outcome assessment. By ensuring consistent SO assessment, a fair evaluation of continuous improvement of a program can be performed. To help achieve this, the research proposed here enables SO assessment instruments to be shared amongst faculty who teach a course within a particular program.

Apart from consistency within a program, a university may strive to achieve consistent SO assessment across programs. Several engineering programs have overlapping topics in their respective curricula. For example, topics from engineering mechanics can be found in mechanical

engineering, industrial engineering, and civil engineering amongst others. As another example, topics based on metal manufacturing processes can be found in manufacturing engineering, mechanical engineering, and industrial engineering program curricula. In such cases, consistency of SO assessment across programs can be beneficial since a subpar assessment related to a common topic can be a symptom of a systemic improvement need. In addition to common topics, certain ABET SOs can be used to evaluate institutional performance across programs. For example, *criterion g* – "an ability to communicate effectively," can have common assessment aspects across programs. A deficiency in *criterion g* across programs can be indicative of a need to improve general education curricula. The system presented in this research will allow for all programs to store and share assessment instruments related to particular SOs and engineering topics in a centralized repository, therefore enabling consistency in their measurement.

Across institutions, sharing SO measurement instruments can be beneficial, and can be the source of future research projects. It is hypothesized that sharing of SO assessment instruments across universities can lead to a crowd-sourcing environment, where the community comes together to converge on a set of "best-practice" SO assessment instruments for a given course/topic. The system proposed can be extended to include several universities, their programs, and their SO measurement instruments. In the next section, the design of the proposed system is presented. This is followed by avenues for future research.

Design of the System

Problem Definition

While preparing for the ABET accreditation process, it becomes evident that the core objective of ABET is to ensure that programs continually monitor and improve themselves. Although assessing SOs are just one of many methods of program monitoring, they are vital since they directly involve student responses to measurement instruments. It is therefore essential to ensure that SO assessment longitudinally (i.e. across time) are consistent and indicative of program health and development. The scope of the problem was defined to be the development of a method to share and standardize SO assessment instruments within the Industrial Engineering program at Francis Marion University, Florence SC.

A web-based Relational Database Management (RDBM) system[6,7] approach was selected due to the following reasons:

i. A web-based approach will allow for geographically dispersed faculty to have access to SO assessment instruments.
ii. RDBM system approach allows for relatively easy and versatile querying of data.
iii. Web-based RDBM system can be administered at a central location and accessed by several universities.

Sample Queries

Prior to developing the Entity-Relationship (ER) model[8] for the RDBM system, a list of potential queries was established. The scope of these queries were limited to a system that was going to be used at Francis Marion University's Industrial Engineering program alone.

i. View all courses and related course descriptions in the program.
ii. Add a course and related description to the system.

iii. View and add ABET SO for a course.
iv. View ABET SO assessment instruments for a course for a given SO.
v. Delete ABET SO assessment instrument for a course for a given SO.
vi. Add notes to an individual ABET SO assessment instrument.
vii. View all notes for a given ABET SO assessment instrument.
viii. Add/Edit ABET SOs.

These queries were used to develop an ER model of the RDBM system. The ER model is presented next.

Entity-Relationship Model
In this section, the entities are described first, followed by a description of the relationship between these entities. Each entity's attributes are listed and a brief description of the entity is provided. Example data for these entities can be found in Figures 1 to 6.

1. ABET Outcome:
Attributes: ID, ABET Letter, ABET Description
Description: This entity is used to capture the ABET SOs. The ID serves as a unique identifier for the entity. The ABET Letter attribute is used to identify the SO based on ABET's naming convention ('a' through 'j'). ABET Description provides the explanation of a particular ABET SO. For example, ABET SO 'g' is 'an ability to communicate effectively'.

2. Course:
Attributes: ID, Name, Description
Description: This entity allows program course information to be stored. The ID attribute is a unique identifier, the Name attribute is used to store the name of the course, and the Description attribute allows for the course description to be stored.

3. Question:
Attributes: ID, Description
Description: This entity is a pseudonym for ABET SO assessment instruments and is used to capture SO assessment instrument information. Again, the ID attribute is a unique identifier, and the Description attribute allows user to describe the ABET SO assessment instrument. The instruments can be, for example, a multiple choice question; or, an essay-type question; or, a problem from a text book; or, a hyperlink to a video.

4. Note:
Attributes: ID, Note
Description: This is used to store notes related to particular SO assessment instruments (Question.) Here, the ID attribute is a unique identifier, Note captures the intent and message, and the QuestionID relates the note to the desired ABET SO assessment instrument (Question.) Notes are used to communicate best practice method of performing the assessment and other information which will help fellow-academicians administer the particular ABET SO assessment.

5. Course is related to ABET Outcome:
Attributes: CourseID, OutcomeID

Description: This is an *m-to-n* relationship which relates courses to particular ABET SOs. Each course can have none, one, or more ABET SO that are assessed in it. Also, an ABET SO can be assessed across multiple courses.

6. Course ABET Outcome is assessed by Questions:
Attributes: CourseID, OutcomeID, QuestionID
Description: This relationship relates courses, their ABET SOs, and the assessment instruments used to measure particular SOs in an individual course.

7. Course ABET Outcome Questions have Notes:
Attributes: NoteID, QuestionID
Description: This relationship relates specific SO assessment instruments to Notes that may accompany them. An individual SO assessment instrument may have several Notes, however, a Note can be related to only a single ABET SO assessment instrument. During normalization, this relationship collapses into the form of a "QuestionID" column on the Note entity.

Implementation
The ER model described above was implemented using MySQL, and a website user interface was created, using HTML and PHP, to query and add to the database. The current version of the system is housed on a local intranet and will be made available for public use after necessary expansions are implemented. Interested fellow academicians can find the SQL file for the database at *http://people.fmarion.edu/rrenu/ASEE-SE2018/*. This SQL file will allow for the creation of the database structure of the current version of the system. With this information, the system can be easily recreated. It must be emphasized that an advanced version of the system is under development. In this advanced version, universities and programs will have read and write access to their data, while also having read access to data from other universities and programs. In the advanced system, user roles will also be defined. An administrative role will allow for a user to add non-administrative users, delete users, and edit ABET SOs. Figures 1 to 6 show the current implementation of the web-based RDBM system.

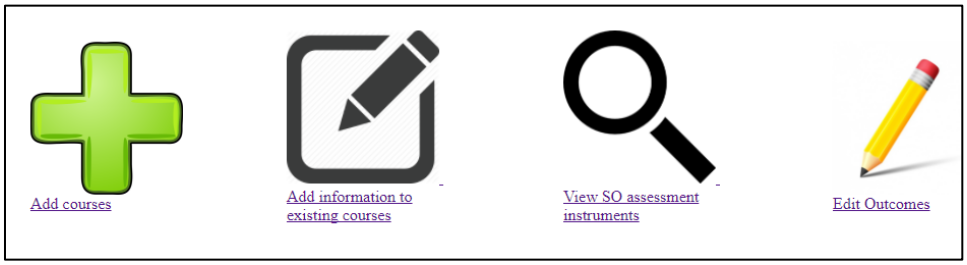


Figure 1: Home page options

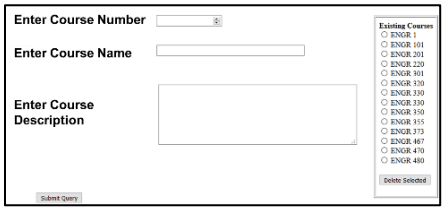


Figure 2: "Add courses" page

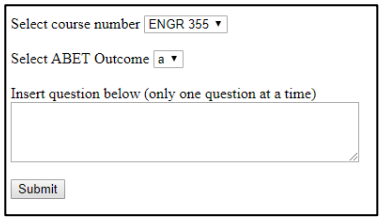
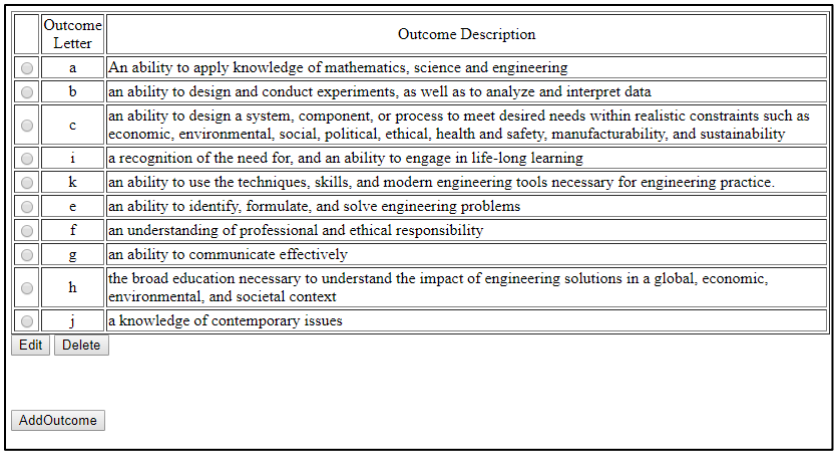


Figure 3: "Add information to existing courses" page

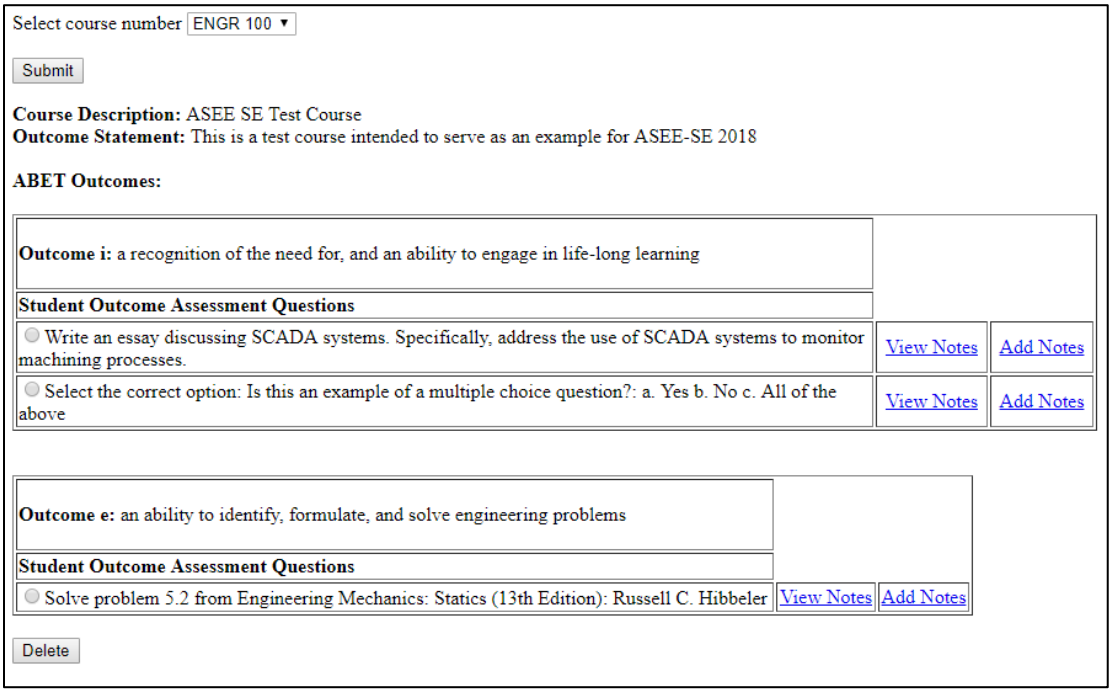


	Outcome Letter	Outcome Description
○	a	An ability to apply knowledge of mathematics, science and engineering
○	b	an ability to design and conduct experiments, as well as to analyze and interpret data
○	c	an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
○	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.
○	e	an ability to identify, formulate, and solve engineering problems
○	f	an understanding of professional and ethical responsibility
○	g	an ability to communicate effectively
○	h	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
○	j	a knowledge of contemporary issues

Edit Delete

AddOutcome

Figure 4: "Edit Outcomes" page



Select course number ENGR 100 ▾

Submit

Course Description: ASEE SE Test Course
Outcome Statement: This is a test course intended to serve as an example for ASEE-SE 2018

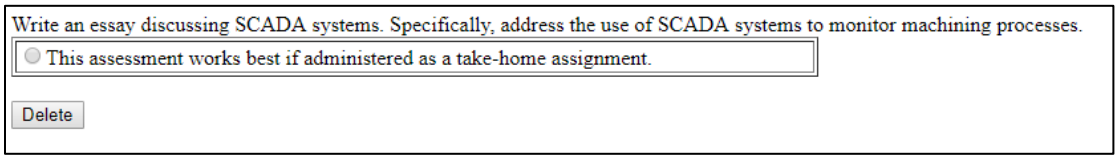
ABET Outcomes:

Outcome i: a recognition of the need for, and an ability to engage in life-long learning		
Student Outcome Assessment Questions		
○ Write an essay discussing SCADA systems. Specifically, address the use of SCADA systems to monitor machining processes.	View Notes	Add Notes
○ Select the correct option: Is this an example of a multiple choice question?: a. Yes b. No c. All of the above	View Notes	Add Notes

Outcome e: an ability to identify, formulate, and solve engineering problems		
Student Outcome Assessment Questions		
○ Solve problem 5.2 from Engineering Mechanics: Statics (13th Edition): Russell C. Hibbeler	View Notes	Add Notes

Delete

Figure 5: "View assessment instruments" page for example course ENGR100



Write an essay discussing SCADA systems. Specifically, address the use of SCADA systems to monitor machining processes.

○ This assessment works best if administered as a take-home assignment.

Delete

Figure 6: "View Notes" page for an example question

Conclusions and Avenues for Future Research

The objective of the overall research is to standardize ABET SO assessment. The research presented in this paper contributes to that goal through the development of a web-based database system to store and share SO assessment instruments, course information, and instructor notes. The system needs further development, and research needs to be performed to assess the impact of the system. The researchers have identified the following avenues for future research.

1. Rubrics for assessment

Subjectivity in assessment of SOs can stem from the assessment instrument used, and can also stem from inherent variations in instructor grading methods. The proposed system can help achieve consistency of assessment instruments used. However, there exists opportunities to develop and share assessment rubrics through the database system to limit subjectivity in grading.

2. Usability study

A usability study must be conducted to ensure that the user interface of the system is intuitive and easy to use. Usability studies are also a method to discover the need for additional functions.

3. Expansion to include multiple universities and programs

The system must be expanded to enable use by multiple universities, multiple users across a university, and multiple user access right levels. For instance, it is conceivable that the system allows user from a particular university to view SO assessment instruments from another university but not have the rights to edit the other university's assessment instruments.

4. Research to investigate level of standardization achieved

When multiple faculty, programs, and universities use the system, research must be performed to verify the level of standardization that the system has introduced. This analysis must investigate level of standardization across faculty within a program and university, across programs in a university, and across universities. It is hypothesized that the academic community will converge on a set of "best practice" SO assessment instruments and rubrics

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