International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 11, Issue 3 [May.-June. 2022] PP: 589-593

ABET Assessment and the Capstone

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Abstract

We describe a semi-automatic assessment system based on a Course Management System (CMS) called Blackboard that enables both formative and summative assessment, by program, for interdisciplinary teams. Program-oriented assessment is critical for ABET, as ABET accredits programs and not departments.
Our student outcomes assessment enables compliance with ABET criteria for standards, realistic constraints, impact, sustainability and a major design experience.

Keywords: ABET, Assessment, EAC, CAC

Date of Submission: 07-06-2022 Date of Acceptance: 22-06-2022

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1. The Problem

ABET (formally known as the Accreditation Board for Engineering and Technology) makes use of a curriculum criterion known as *Criterion 5*. The curriculum criterion requires that programs provide evidence of "a culminating major engineering design experience that 1) incorporates appropriate engineering standards and multiple constraints, and 2) is based on the knowledge and skills acquired in earlier course work."
How do we know when we are compliant with the "major engineering design experience" with "appropriate engineering standards" and "multiple constraints" criterion? Where should the standards and constraints outcomes be measured? How can we have program-oriented measurement of these things when we have interdisciplinary teams? Direct examination of student work is only effective on a team-basis when the team is from the same program. Thus interdisciplinary teams confound program-oriented evaluation and yet provide intrinsic value that many programs have embraced.
We became aware of data comingling during several visits, by Prof. Lyon, as both a Program Evaluator and ABET Commissioner. The issues raised motivated us to to study this problem as because it impacts 4,361 programs accredited at 850 institutions in 41 countries. More than 970 of these are located outside of the U.S., accounting for over 20 percent of all ABET-accredited programs in the 2020-2021 time frame. Thus, this is an international and widely felt problem[1].

2. Prior Work

Our process for evaluation is centered on the capstone course and is similar to the approach described by McCullough, except that we have shown how to isolate assessment data so that it is program-based[2]. The McCullough approach was acceptable in their institution because they did not have interdisciplinary teams and thus, team-based assessment did not comingle data across various programs. Summative and formative assessment for ABET outcomes is not new[3]. What is new is our means of automation of the summative assessments so that data may be collected in an automatic manner, thus facilitating the closing of the loop. Formative assessment and closing the loop still requires manual intervention (and we are not optimistic that this can be changed in the near future).

3. Automation of Summative Assessment

This section describes the automation of summative assessment using the *BlackBoard* system. We have devised an instrument, along with an answer key to facilitate automatic grading. Sample questions for standards appear below:

1. (True/False) ISO is a standard (International Standard Organization)
2. (True/False) A norm (i.e. a social norm) can be a standard

3. (True/False) A method of development can be standardized and thus be a standard
4. (True/False) The waterfall model of software engineering is a standard design
5. (True/False) Patterns of engineering design are never standards.
6. (True/False) Standards are everywhere, from electrical connectors, to standardized page sizes, to power requirements, to nuts and bolts, etc. We are surrounded with standards and they enable us to have interchangeable parts and design from known specifications. Etc.

Not all questions are true/false questions (some are multiple or multi-choice). In any case, with a properly coded answer key, we can produce a student outcome that leads to an individual grade (automatically). In the area of realistic constraints, we can perform the same type of assessment;

7. (True/False) You can have social constraints
8. (True/False) Designs can favor some kinds of people but not others
9. (True/False) Designs can favor employers
10. (True/False) Designs are developed with public funding
11. (True/False) Some designs pose negative side effects for a specific race or gender
12. (True/False) Some designs infringe on existing patents or copyrights
13. (True/False) Some designs are not safe for children
14. (True/False) Price is a realistic constraint.
15. (True/False) Potential impact to the local economy is a realistic constraint. Etc.

4. Societal Impact and Sustainability

Summative assessment with automatic grading is achieved in much the same way for societal impact and sustainability as it is for realistic constraints and standards. An excerpt of our summative instrument follows:

1) How many gallons of motor gasoline does the average American consume in one year?
a) 150 gallons
b) 500 gallons
c) 310 gallons
d) 750 gallons
2) (True/False) Biodiversity is the variety of ecosystems on Earth
3) Of the following indications of the health of a water body, which is the most widely accepted means of measuring how polluting an effuent is?
a) BOD (biological oxygen demand)
b) COD (chemical oxygen demand)
c) Chloroform content
4) Which of the following sources of energy is NOT renewable?
a) Petroleum
b) Hydro Power
c) Biomass
d) Solar power
5) Name of the International agreement by 37 industrialized countries and the European community for reducing greenhouse gas (GHG) emissions
a) Timeplex Protocol
b) Kyoto protocol
c) Green Protocol
6) What is the most serious threat to biodiversity?
a) Habitat loss
b) Tourists
c) Pollution
7) The industry responsible for the greatest anthropogenic (human activity related) release of methane into the atmosphere is:
a) Energy
b) Transportation
c) Agriculture
d) Waste Treatment
8) Three key areas of sustainability are…
a) Political, energy, and recycling
b) Economic, social, and political
c) Social, environmental and economic
d) Recycling, biodiversity, and social

9) (True/False) Climate change only started with the Industrial Revolution.
10) Which of the following is NOT a strategy for increasing Earth's sustainability?
a) Crop rotation
b) Using recycled materials
c) Designating land as wilderness
d) Increasing the size of industrial farms
11) Which of the following best describes economic sustainability?
a) Investments with internal technology
b) Focusing sales to market needs
c) Anti-corruption policies
d) Corporate citizenship
12) Which of the following lowers your carbon footprint?
a) Riding a bike to College
b) Driving a car to the shops
c) Taking a plane to Spain
13) Improving education opportunities can help (check all that apply):
a) Improve family planning options
b) Reduce poverty
c) Increase family size
d) Prevent destruction of natural habitats
14) According to the 2009 Greening of Corporate America research study, what is a driver of sustainability today?
a) Profitable growth
b) Protecting the environment and improving quality of life
c) Market differentiation
d) All of the above
15) Which country is overall the highest emitter of CO_2 at the moment?
a) United States of America
b) China
c) Brazil
16) Providing good conditions for workers is:
a) Not important
b) A moral issue
c) A design issue
d) A recycling issue
17) How can consumers help promote supply chain transparency?
a) Buying garments that meet environmental certifications
b) Purchasing garments from big-box retailers
c) Buying garments made locally or made in the USA
d) Buying garments that meet environmental certifications and Buying garments that meet environmental certifications
18) (True/False) Sustainability is the use of a resource that doesn't cause long-term depletion of the resource or affect the diversity of the ecosystem. Etc.

5. Graphical Data Summary

We find a graphical summary of the data gathered to be particularly useful to demonstrate compliance with criteria.

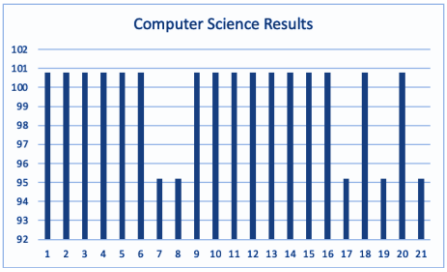

Figure 1. CS Local and Global Societal Impact

Figure 1 shows the summative results from Local and Global Societal Impact by students from the computer science program. According to the data collected, 76% of students within the computer science program returned perfect scores upon completion.

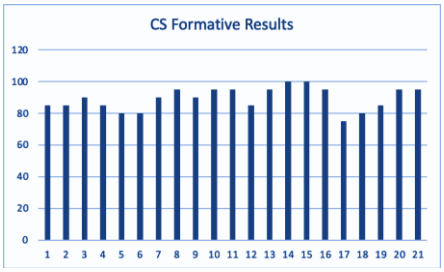

Figure 2. CS Sustainability

Figure 2 shows the summative results from Sustainability by students from the computer science program. According to the data collected, 95.2% of students within the computer science program received scores 80% or higher. With the raw summative data, formatting graphs with different styles is easy, within Excel.

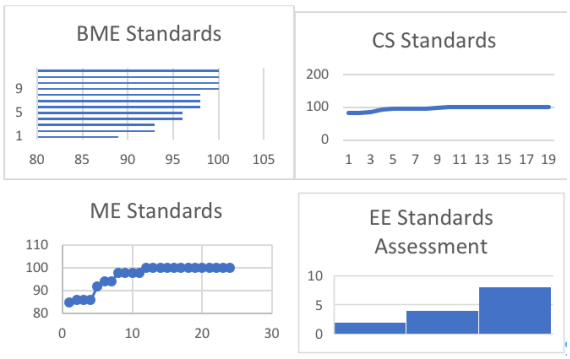

Figure 3. Summative Assessment of Standards

Figure 3 shows various formatting techniques for demonstrating the summative assessment for the standards outcome, listed by program.

6. Formative Assessment

This section described the formative assessment instrument administered to each student in order to provide evidence of standards. Each student is required to submit an essay that enables a demonstration of their level of understand of standards and how it relates to their project.
Please list your:
Name;
Major;
Project Title:
And 5 standards in the format:
1. exact standard title, standard number, and standard publication year
This is not a group assignment, each student submits their own work describing why the standard is important, how it impacts the design and how the standard relates to the major of the student. So, an electrical engineer may look into IEEE standards, FCC standards, etc. A biomedical engineering may look at FDA regulations and related standards, etc.
The rubric for the assessment includes an automatic screening system called “safe-assign” that checks for plagiarism. However, even with this level of automation, manual grading is still required and we do not anticipate that this will change in the near future.

7. Major Design Experience

Formative assessment of the major design experience takes the form of an essay written by a subset of each team describing their majors’ contribution to the design of the project. For example, the computer science majors write about software design, electrical engineers about electrical aspects of the design and the

mechanical engineers about their contributions to the mechanical aspects of design, etc. Assessment is a manual activity as with other formative assessment. Students are instructed to discuss the design impact on, public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. Multiple approaches are a requirement in the discussion, as well as the process for approach selection. Discussion includes the development and use of design methodology, formulation of design problem statements, consideration of alternative solutions, feasibility considerations, and detailed system descriptions. The rubric for grading centers on the iterative decision- making process, in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective.

8. Evaluation

ABET defines evaluation as a process for interpreting assessment data and determining the extent to which student outcomes are being attained. The evaluation results in decisions and actions regarding program improvement. We have a wrap-up session in our program that makes use of the assessment data and then makes changes to our program so that we can close the loop. The evaluation and resultant actions are the direct result of our evaluation of student performance and documented in the meeting minutes.

9. Summary

ABET compliant assessment of program-level curriculum requires measurable outcomes for students within the curriculum. Assessing and evaluating the outcomes enables continuously adjusting to improve the curriculum. Skills in the area of standards, realistic constraints and design are required of all programs and assessing these items in the capstone seems like a logical (and indeed prevalent) thing to do. Continuous improvement is a process that involves both assessment and evaluation. This paper shows one way to identify, collect and prepare data to evaluate the attainment of student outcomes in the area of standards. We use direct quantitative and qualitative measures to meet the ABET definition of assessment.

10. References

[1]. Private e-mail sent to ABET Program Evaluators on December 20, 2021.
[2]. C. L. McCullough, "A Plan to Assess All the New ABET Outcomes Using Only Three Courses," ASEE Southeastern Section Conference, 2018.
[3]. Bloom, B. S.; Engelhart, M. D.; Furst, E. J.; Hill, W. H.; Krathwohl, D. R. Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York: David McKay Company, 1956