Outcomes Assessment Embedded into an ECE Course Project

Leonard J. Bohmann and Bruce A. Mork
Michigan Tech

Abstract

In an effort to reduce the overhead associated with outcomes assessment, the Electrical and Computer Engineering Department at Michigan Tech has developed tools which extract assessment data from information collected for normal departmental operations. The ECE department has developed one such tool to assess the writing skills of students in their Junior year. A conceptual design project is assigned in a required course (the most recent project was an off-the-grid power system for a remote cabin) with students completing a written report describing their results. A grading rubric has been developed assessing both the quality of the technical result and the quality of the writing. The rubric scores for the writing are extracted and reported as part of our annual assessment efforts. This process is being expanded to include assessment of life-long learning skills.

Introduction

Assessment is not only required by ABET but, more importantly, it is central to the continuous improvement of educational programs. Given the time constraints of faculty, the assessment process needs to be as efficient as possible. The need for efficiency is made further evident when one realizes that an effective assessment program must rely on multiple measures and demonstrate the abilities of all students. This has lead to the conclusion that embedding assessment processes into existing faculty duties, such as grading, is not only prudent but necessary in order to have a sustainable assessment program.

The Project

In the required course, EE 3120 – Introduction to Energy Systems, the students are required to write a paper describing a design project. The particular design project changes from semester to semester, with a recent example being the preliminary design of an electrical power system for an off-the-grid residence. Past projects have included the use of either a wind turbine or photovoltaic panels as the energy source.

Using the off-the-grid- project as an example, the student's first step is determining the geographic location for the residence. They are given a limited area from which to choose, typically a list of several states. The location will determine the energy resource available, either the solar insolation or the average annual wind speed. The students are given the URLs for websites maintained by the U.S. Department of Energy which contain this data[1, 2].

The next step for the student is to determine the average electrical energy usage. There are two approaches. The first is to list all the electrical loads needed in the residence, their power requirements, and the amount of time that they are used. This is a very informative exercise for the students. It makes them think about the energy they use to maintain their lifestyle. The results fall within two extremes, those who plan on a very austere lifestyle and those who plan on enjoying the stereotypical American way of life.

The second approach for determining the load is to obtain the data for an existing dwelling. This does not give the students as much insight into the details of their energy use, but it does give a more accurate accounting. This is of particular help for those who are coming up with a preliminary design for an actual residence, for example a hunting camp or a summer retreat that their family owns.

In their reports, each student is required to document on how they plan on powering their major loads; refrigeration, water supply, heating, air conditioning, cooking, and laundry facilities. Here the student's choice of location comes into play. The need for heating and air conditioning is determined by the local climate. The distance from the nearest town determines the availability of city water and natural gas or propane.

With the average electrical energy usage determined, the components of the electrical supply system can be specified. The students are asked to specify four major components; the energy source (a wind turbine or solar array), a battery bank to store the energy needed to match the energy production to the energy needs, a charge controller necessary to interface the energy source with the batteries, and, if required, an inverter needed to match the dc electrical production system to the ac electrical utilization system. The students are asked to provide model numbers, the prices, the vendor, and the specification sheets for each component.

To correctly specify the components, the students have to match the energy production of their source to their energy usage. They need to match energy storage requirements to the variability of their energy source. They need to match their charge controller to the voltage and current production of their source as well as the voltage of their batteries. Finally, they need to match their inverter to the voltage and power requirements of their loads and to the voltage of their batteries.

The students are then asked to write a two-page paper describing their design. They are asked to include the location of their residence, including a short description of the surroundings (urban, suburban, rural, etc.). They also include a discussion of the electrical loads in the residence and a discussion of the over all electrical system. Appendices are included that contain design calculations, product literature, and a sketch of the electrical connections.

Assessment of Written Communication Skills

The ABET Criterion 3g states, "Engineering programs must demonstrate that their graduates have: ... an ability to communicate effectively"[3]. To satisfy this criterion we insist that our students demonstrate that they can write effectively and that they can give effective oral presentations. We had previously used Senior Design reports to assess the students writing ability but have recently changed to assessing the written report described above. Our Senior Design is a group project and the team writes the report. The teams' best writer composes the majority of the report; so assessing the writing is not assessing the writing ability of all the students. This assessed only 20% - 25% of the students and it was far from a random sampling, as typically the best writer would volunteer for the task.

In order to minimize the extra work required for outcomes assessment, it was incorporated into the grading of the reports. A rubric was developed to grade the students' work. This is shown in Figure 1 below.

Attribute	0 Unacceptable	2 Below Expectations	4 Meets Expectations	5 Exceeds Expectations
Report Mechanics				
Organization	Inappropriate content in most sections of report	Some inappropriate content in some sections of report	Content appropriate in all sections of report	Unique organization enhances readability and/or understandability of report
Format	Tables and figures can not be read/understood, fonts difficult to read, so many format errors as to make the report useless	Some portions are sloppy and difficult to read, some format errors	Text, tables, figures are readable and understandable.	Text, tables, figures so clear and understandable as to enhance the report's impact, unique format enhances report's impact
Grammar, Punctuation, Spelling	Excessive spelling, grammar, and punctuation errors	Some spelling, grammar, and punctuation errors	Only a few spelling, grammar, and punctuation errors	Completely free of spelling, grammar, and punctuation errors
Length	Far too long or too short	Too long or too short		Appropriate report length
Content				
Project Location	absent	only gives geographic location	tells if area is rural/urban and types of utilities	description gives clear sense of place and gives enough detail to easily determine mean wind speed
loads	absent	vague description	tells how get heat, H_2O heat, cook, water, laundry	Clear description of lifestyle and loads required
system discussion	absent	brief discussion of components	description of components and why they are picked	discuss components as well as voltage levels and battery reserves chosen.
Calculations				
load calculation	not given	major error in calculations or assumptions	minor error in calculations or assumptions	complete accounting of loads
turbine size calculation	not given	major error in calculations or assumptions	minor error in calculations or assumptions	turbine is correct size
battery size calculation	not given	batteries specified wrong V or I for bank size	batteries specified are wrong stored energy for bank specified	Batteries specified match bank specification
charge controller	not given	major error in calculations or assumptions	minor error in calculations or assumptions	controller will work w/ turbine
inverter calculation	not given	major error in calculations or assumptions	minor error in calculations or assumptions	inverter will work with loads given
Other Appendices				
equipment list	not given	incomplete list	complete list and incomplete data	complete list with complete data
cut sheets	not given	incomplete set	complete set w/ incomplete data	complete set with complete data
electrical sketch	not given	major inaccuracies	minor inaccuracies	complete
resources used	not given	incomplete references	minor inaccuracies	enough data to easily find resources

Figure 1: Paper Scoring Rubric

When grading the students' work all attributes are used. When assessing the students' writing ability, only the attributes under the heading "Report Mechanics" are used.

This method has been used twice, once in Fall 2003 and again in Fall 2004. In 2003 there were 71 students in the class and in Fall 2004 there were 56 students. The scale is 0-5, with 0 as Unacceptable, 2 as Below Expectations, 4 as Meets Expectations, and 5 as Exceeds Expectations. The average scores for each subsection were:

	Fall 2003	Fall 2004
Organization:	4.27	4.30
Format:	4.25	4.34
Grammar, Punctuation, and Spelling:	3.89	4.00
Length:	4.38	4.80
Average:	4.25	4.36

This data indicates that the students in Fall 2003 and Fall 2004 meet our expectations in their ability to write a technical report. The area in which they were weakest is in Grammar, Punctuation, and Spelling. In Fall 2003 this sub-section had 13 students scoring Below Expectations or Unacceptable, while in Fall 2004 there were only 6 students with these scores.

Assessment of Life Long Learning

Beginning in Fall 2004, Criterion 3i ("Engineering programs must demonstrate that their graduates have: ... a recognition of the need for, and an ability to engage in life-long learning"[3]) was also assessed using the same written report. In order to do this, very little time was spent in class discussing the project. A web page was developed containing the information the students needed to get started on the project[4]. They were expected to learn on their own, demonstrating the key characteristic of life-long learning. The students had to learn what was needed to design a system that would work for the load that they specified.

In assessing this ability, only the attributes under the heading "Calculations" were used. These attributes form the heart of the technical task the students were assigned. The average scores for this subsection were:

	Fall 2004
Load Calculation:	4.61
Turbine Size Calculation:	2.39
Battery Size Calculation:	3.29
Charge Controller:	4.04
Inverter Calculation	3.96
Average:	3.66

The average of all these subsections, 3.66, is much closer to Meets Expectations (4) than it is to Below Expectations (2), but it is significantly below the average score used for assessing writing skills. The scores for the individual tasks vary considerably. The students were able to learn the material required for the Load Calculations, while a large number did not understand what was required to size the wind turbine correctly. The variation in scores indicates that students were able to learn some material on their own (the key skill in life-long learning), but not all of it. This indicates that there may be a problem with the assignment, with some material presented better than others. After reviewing the assignment, this does seem to be the case and it will be modified before it is assigned again.

Assessing the Assessment Tools

As should be done with any assessment process, this one is monitored for its effectiveness and ease of use. The results are analyzed to determine if they are actually measuring what the process was designed to measure. The process is analyzed to determine if it can be made more efficient. The assessment of written communication skills does measure what is intended. It is sufficiently general so that the same rubric can be applied to different assignments as they change from semester to semester. This allows a valid comparison from one semester to the next. As discussed above, the assessment if life-long learning did not accurately measure the desired skills, but instead measured an inconsistency with the assignment. Another difficulty with the life-long learning assessment is the rubric that was used. It is specific to the project assigned to students in Fall 2004 and a new rubric is need each time the student assignment is changed. A future task is to determine a life-long learning rubric that is more general and will allow more detailed comparisons from one semester to the next.

Conclusion

Streamlining the assessment process is the best way to make it sustainable. One of the simplest methods of doing this is to use what is already being done for assessment purposes. It is often difficult to use student grades as an assessment tool since the grades are a measure of many different abilities. But by judiciously defining a grading rubric, assessment of particular students abilities can easily be made. This minimizes the additional work of collecting assessment data, leaving more time for its evaluation and for the needed program improvement brought to light by the evaluation.

Bibliographic Information

1. Wind and Hydropower Technologies Program: Wind Powering America, U.S. Department of Energy, Energy Efficiency and Renewable Energy, http://www.eere.energy.gov/windandhydro/windpoweringamerica/, 2005.
2. U.S. Solar Radiation Resource Maps, National Renewable Energy Lab, Renewable Resource Data Center, http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/atlas/, 2005.
3. Criteria For Accrediting Engineering Programs, ABET Engineering Accreditation Commission, November, 2003.
4. EE 3120 Term Paper, Leonard J. Bohmann, Michigan Tech, http://www.ece.mtu.edu/faculty/ljbohman/Courses/3120F04/Wind_Design.htm, 2004.

Biographical Information

LEONARD J. BOHMANN is an Associate Professor of Electrical Engineering with a specialization in Power Systems and has worked at Michigan Tech since 1989. He received his Ph.D. (1989) and MSEE (1985) from the University of Wisconsin - Madison and his BEE (1983) degree from the University of Dayton. He was instrumental in the development of a Computer Engineering program in 2000 and he also served as the department's curriculum coordinator during Michigan Tech's recent conversion from quarters to semesters. Dr. Bohmann is a member ASEE, IEEE, and Tau Betta Pi and is a registered Professional Engineer in the State of Michigan.

BRUCE A. MORK joined the faculty of Michigan Technological University in 1992, where he is now Associate Professor of Electrical Engineering. He received the BSME, MSEE, and Ph.D. (Electrical Engineering) from North Dakota State University in 1979, 1981 and 1992 respectively. From 1982 - 1986 he worked for Burns and McDonnell Engineering. He has spent 3 years in Norway, working for the Norwegian State Power Board in Oslo, as visiting researcher at the Norwegian Institute of Technology in Trondheim; and as visiting Senior Scientist at SINTEF Energy Research, Trondheim. Dr. Mork is a member of IEEE, ASEE, NSPE, and Sigma Xi. He is a registered Professional Engineer in the states of Missouri and North Dakota.