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Assessing the Effectiveness of Problem and Project Based Learning in a Green Building Design and Construction Course Using ETAC Criteria

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Abstract: Sustainable design practices have become more prevalent in the fields of Civil and Construction Engineering Technology and traditional Civil Engineering. Therefore, educators must prepare the next generation of engineers with courses on sustainable engineering and incorporate sustainable topics into traditional engineering subjects. Such is the case at Youngstown State University where the first course in LEED (Leadership in Energy and Environmental Design) was taught Fall semester 2012. The course used the USGBC LEED Reference Guide for Green Building Design and Construction as the basis for learning. The students were asked to learn the aforementioned USGBC publication through traditional classroom lectures, case studies and projects. Each of the case studies and the final project used Problem and Project Based learning principles to allow the students to gain greater understanding of the material. The effectiveness of this was assessed using ETAC learning outcomes. This was done by choosing specific outcomes to be evaluated and then evaluating each assignment and test based on the outcomes which reflect what the students were supposed to learn. This paper describes the Problem and Project based methodology used and the approach to selecting the ETAC outcomes used to assess the student learning. Also discussed will be the process of setting up and analyzing the rubrics used to get meaningful data and results of the student learning.

Keywords: ETAC-ABET, LEED, Problem and Project Based Learning, USGBC

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Introduction and Background

Due to national trends which indicate an increasing number of "green building" design projects and based on the suggestion of the Civil and Construction Engineering Technology (CCET) Industrial Advisory Board (IAB) at Youngstown State University, the CCET program has begun to implement sustainable engineering topics into a variety of classes. However, up until the fall semester 2012 there has never been a class totally devoted to sustainable practices. The first class of this type revolved around LEED principles and used the USGBC *LEED Reference Guide for Green Building Design and Construction* (USGBC, 2009) as the basis for lecture materials. The assignments for the class were developed using Problem and Project based learning methodology. This gave the students in the class the freedom to formulate their own solutions, based on the USGBC *Guide*, to various case studies discussed or given as graded assignments. The case studies, which are very open-ended in nature, require the students to use the information in the USGBC *Guide* and the information given in the case study to explain how LEED credit was given on the project described in the case study. Also, required of the students was an explanation of what additional LEED credit could have been received on the project if other design items were added to the original project. Thus, the students were evaluating these case study scenario's based on what was present and what could be added which leads to a greater and deeper level of understanding. This follows the contention of Sancho, Fuentes, Gomez-Martin and Fernandez-Manjon (2009, 668) stating Problem and Project Based Learning "leads to deeper levels of learning, critical thinking, shared understanding, and long-term retention of the learning materials".

Problem and Project Based Learning Relevance

Problem and Project Based Learning (PBL) has many relevant and meaningful definitions. However, in his manuscript from 2006 (9), John R. Savery describes it as "an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem". Jonassen and Hung (2008, 15) state "The primary goal of PBL is to enhance students' application of knowledge, problem solving, and self-directed learning skills by requiring them to actively articulate, understand, and solve problems". Furthermore, PBL problems should be open-ended, ill structured, challenging and engage the student's interests. They should also enhance the students understanding of the field as it pertains to future workplaces (Jonassen et.al. 16). These statements truly exemplify the applicability of using PBL methodology to reinforce LEED concepts to a group of junior/senior level students at Youngstown State University. Usually, engineering technology and traditional engineering curricula are very focused on analysis and design technical courses without relating the topics to actual industrial practice (Mills et. al., 3). As educators, we strive to sharpen the problem solving skills of the students by giving them assignments which require them to apply the theory behind the subject matter being studied. We also wish to sharpen their critical thinking skills by assigning open-ended, "real world" case studies and projects which require them to interpret and evaluate data and then draw meaningful conclusions. These "real world" situations not only help explain the material, but

they give the students a glimpse of what types of situations they will encounter while practicing engineering technology.

The lecture format of the course offers an ideal way to emphasize the importance of the aforementioned critical thinking skills in two main ways. First, during our lectures, the faculty member and the students interact which allows for a convivial atmosphere. This atmosphere encourages the students to interject their ideas into the discussion. This corresponds with the aforementioned Jonassen and Hung quote. The soft structured nature of the selected case studies allows the students the freedom to apply the LEED principles from the USGBC *Guide* to the existing information and then to subsequently use their creativity in projecting what LEED items could be added to the project to achieve more LEED credit. This also aligns with the contention of Savery (2006, 12) who states "critical to the success of the approach is the selection of ill-structured problems (often inter-disciplinary) and a tutor who guides the learning process and conducts a thorough debriefing at the conclusion of the learning experience"[3]. Therefore, through these types of lecture sessions, the students and the instructor discuss the specifics of the LEED manual by engaging in meaningful conversations similar to what would be done in the workforce.

Lastly, since LEED is primarily regulatory in nature, the course featured extensive use of secondary teaching and learning resources. One of the learning resources used in the lecture was the vast array of web sites which help the LEED professional apply the LEED regulations to various situations. Many of the LEED regulations and guidelines for applying them to specific cases are located on various on-line web sites. Therefore, another "real world" principal that was able to be reinforced was seeking out information in secondary resources (government regulation sites etc.) to be used to further explain the LEED guide and subsequently develop further analysis points of the cases studies. These web sites also help the students gain a deeper understanding of the regulations in the USGBC *Guide* by offering more in-depth explanations of the *Guides* content. The web addresses also give more insight into all of the "team members" who are required to work together to gain certain LEED credits and also explain the process preparing the paper work/forms required to achieve certain credits. Therefore, the lecture format of the class and the large final project assignment firmly exemplify the main objectives of PBL as stated by Sancho et al. (2009, 668) which is "building on prior knowledge, problem solving, the use of critical thinking approaches and reflection".

Selection of ETAC outcomes and assessment techniques

Evaluating the effectiveness of this new course offering can be difficult since LEED subjects are very regulatory in nature and substantially different than traditional engineering technology topics. To counteract this situation, ETAC (http://www.abet.org) learning outcomes were chosen by the course instructor and used as the basis for the assessment. This was done for two reasons. First, Youngstown State University's Engineering Technology program uses various ETAC outcomes to evaluate learning outcomes in every class and in every degree program which provided a level of familiarity to the faculty member performing the assessment. Secondly, and most importantly, ETAC outcomes are very specific and speak to certain desired learning outcomes. Therefore, the outcomes selected were chosen because they pertained to what the course instructor hoped the students would learn and retain from the course. In this way, the course assignments could be formulated with these outcomes in mind which assisted the instructor in the assessment of the learning achieved by each student.

Assessment Approach and Rubrics

It was decided that the initial offering of this class would be evaluated using the following four (4) ETAC-ABET outcomes. Each outcome speaks to a different area of learning which pertains to the breadth and depth of learning required in an upper division (junior/senior level) class. The outcomes assessed (identified by their ETAC labels) are listed below.

A – Mastery of knowledge, skills and tools of CCET
D – Ability to apply creativity in design of systems, components and processes
G – Communicate Effectively
H – Recognize the need for lifelong learning

In order to assess the students work based on these outcomes, each assignment needed to be formulated in such a way that one or all of the outcomes could be assessed. Therefore, each assignment (typically case studies and exams) was carefully selected. Each case study was selected in order to assess certain outcomes listed above. Furthermore, each exam question was designed to allow for one or more of the desired criteria to be evaluated. Each of the outcomes was assessed throughout the semester and the results were normalized to a value of four (4). This was done for one main reason. When using ETAC-ABET outcomes to evaluate student learning in engineering technology courses at Youngstown State University, it is customary to strive to achieve a normalized score of 2.85 on a scale of 4.0. This value indicates that the learning by students was sufficient.

Results and Discussion

The following table summarizes each outcome assessed over the course of the semester. Eight different assignments (case studies and exams) were assessed in order to assess each outcome multiple times. This gave a larger set of data to evaluate student learning.

Table 1: Results (Fall Semester 2012)

ETAC – ABET Outcomes Assessed after first course offering (Fall 2012)					
Assignment Number Fall 2012		**A**	**D**	**G**	**H**
	1	2.3	3.0	3.3	2.7
	2	3.0	3.0	3.0	3.0
	3	2.7	2.9	2.7	2.9
	4	3.2	2.7	3.7	3.1
	5	3.7	3.2	3.3	3.1
	6	3.6	3.0	3.0	2.9
	7	3.5	3.1	3.1	3.0
	8	3.6	3.6	3.7	3.6

From the tabulated results above, one can see that many of the outcomes have either met or exceeded the Youngstown State University ETAC-ABET cutoff criteria for a successful

achievement. In subsequent offerings of the LEED class (Spring 2014), we hope to continue with similar course content and assignments. This will allow for a more thorough and statistically relevant analysis because there will be more data, similar in nature to what was accumulated in the first offering in order to draw conclusions.

Summary, Conclusions and Proposed Adjustments

While we were pleased with the results from the first offering of the course, we are going to seek continuous improvement by updating the content where applicable. This includes adding in new homework assignments, case studies and final project which incorporates varied areas discussed in the lecture portion of the course. In order to acquire input from the students at the end of the semester, we requested that students complete a survey which indicated what portions of the class they enjoyed and what potential improvements could be made in subsequent offerings. Some of the comments made were thoughtful and insightful and will be taken into consideration for the next offering. Some of the more thought provoking comments dealt with students wanting more introductory material on how LEED credits are assigned to projects while some students wanted more detail on how much LEED criteria garners certain LEED classifications (i.e. How many criteria are required to attain silver, gold and platinum project ratings). Several students indicated that they would like more case study assignments because the case studies allowed them to gain a more in depth understanding of the lecture material/USGBC *Guide*. Finally, most of the students indicated that they really enjoyed the class project because it allowed them to explore the USGBC *Guide* and all of the websites pertaining to the material which will benefit them as they graduate and join the workforce as practicing engineering technologists.

In conclusion, the first offering of the LEED course was successful on many levels. First, Youngstown State University and The School of Engineering Technology now have a class that is completely devoted to sustainable practices. Second, the course is based on the USGBC manual which outlines LEED guidelines that students may refer to while practicing. Finally, many of the assessments of the course based on ETAC-ABET criteria were above the stated minimum which would indicate that the learning outcomes selected were attained during the course.

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