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Assessment of A Core Class on Sustainability

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Abstract: This paper seeks to present the findings of an effort to teach sustainability through an undergraduate core class focusing on the topic. The findings have been spread out over two semesters. The course under consideration is open to students from any major across the university. It is offered by the department of mechanical engineering at a university in the southeast United States. It emphasizes aspects related to global sustainability. The course focuses on shedding light on sustainability related issues such as environmental pollution, resource utilization, and economics of sustainability. It resorts to innovative design practices as well as novel product ideas as a tool to enhance sustainability. To this end, the course emphasizes hands on learning through design, development and analysis of products from the point of view of sustainability. Assessment results of the final projects have been presented in this paper. Student learning is measured as it relates to each of the three pillars of sustainability. The measurement is done using a rubric specifically designed for the purpose. Additionally, continuous improvement efforts undertaken to further enhance student learning are also presented.

Keywords: assessment, product design, student learning, sustainability, three pillars

1. Introduction

Sustainability is defined as the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs. The objective of sustainability is to improve the quality of human life while living within the carrying constraints of the supporting ecosystems. The aforementioned constraints are often biophysical in nature. Ecosystems are subject to two types of strain: elastic or plastic. Elastic strain is characterized by the ability of an ecosystem to regain its original properties once the stress has been removed. Conversely, ecosystems that are subjected to plastic strain are often not able to retain their original characteristics, thereby undergoing a severe deterioration over time.

Sustainability is comprised of three main pillars: environmental, social and economic. In order to qualify as a sustainable practice or a sustainable solution to a problem, the issues covered under all three pillars need to be addressed simultaneously. For example, a product cannot be termed as being sustainable if it encourages environmental conservation, but ignores the economics and social cost of that conservation. In other words, the question can be asked: conservation, but at what cost (economic and social cost)?

Sustainability related topics are being increasingly taught at many universities across the United States (Segalas et al, 2010, Rusinsko, 2010, Domask, 2007). It would not be a stretch to say that it is a hot topic. TCGT 1530: Global sustainability and Innovation is a core class offered at Georgia Southern University. It is offered throughout the year and is open to students from all majors across the university. The class usually has about 125-150 students in one section. Students from a variety of majors such as political science, music management, humanities, foreign languages, business and marketing etc. are enrolled in the course. Course content focuses on topics such as definitions of sustainability, environmental conservation, and energy sources (including conventional and non-conventional sources), Water, water pollution and desalination as well as sustainable water management, manufacturing methods, the concept of reverse supply chain, closing the loop through green manufacturing and the economics of sustainability. Students are evaluated on their performance on four exams (including a final exam), an in class group debate (debating the pros and cons of a specific technology for instance) and a final project. Students are free to work in groups or individually on the final project. In terms of topical coverage, the basic information is imparted in addition to quantifiable parameters in terms of pros and cons of different technologies. For instance, the principle of solar power is explained in detail (scientific basis), different types of solar power are explained (such as Concentrated Solar power, photovoltaics and solar paint), as is the deficiency associated with the technology (efficiency of most PV panels is about 20-25% only). Students are then encouraged to apply principles learned in class to real world projects whereby they can seek to further the cause of sustainability. The focus of the class is to solve problems through proactive product design whereby resources can be used repeatedly as long as such use is done on a sustainable basis.

The final project accounts for 15 % of the final grade. Participation in the final project is mandatory and it encourages students to think creatively about environmental issues. Some students choose to work in groups (no more than 4 students per group), while others prefer to work by themselves. It has been observed that students that work by themselves are often the more creatively inclined and arrive at a more comprehensive solution than students working in groups. One of the main requirements of the final project is that students create a physical working prototype of a product or process that they are trying to improve (even infinitesimal improvements count for credit). Alternatively, said product or process could be a brand new invention that could replace an existing product/process. This prototype is brought to class and presented during the final week of the semester. Accompanying the physical prototype is a presentation of how the product/process contributes to enhanced sustainability: Does it simultaneously achieve conservation, profitability and develop a social following? To this end, an economic analysis of the product is conducted. The cost for building the prototype is computed. The selling price is ascertained. This is generally a function of the maximum price that the market will bear (if there is a market for that product, a survey of a minimum of about 30 customers will reveal the mean selling price along with the standard deviation) and not based on a standard 'mark up' above total cost. Given this background, the profitability of the product can be computed by calculating the profit margin per unit. The thinking is that if the product and business as a whole is profitable, more people might want to get in on it, thus building a social following. Thus, the practice of sustainability would not necessarily have to depend upon public subsidies, rather it would be self-sustaining.

2. Assessment Results

2.1 Learning Outcomes

The project offered in this course is used to measure student learning outcome based on area D. The Learning outcome is stated as follows: *Learning Outcomes: Area D: Students will apply foundational principles of science, math or technology to the process of scientific inquiry*. In order to measure this outcome, student performance on the aforementioned final project is assessed. This is a group project with no more than four students in the group. Often students feel comfortable to work individually. If such is the case, a score of '0' is assigned to the measure 'Teamwork'.

Measures: The final project consists of a product prototype which incorporates the three pillars of sustainability namely: Environmental conservation, social involvement and economic sustainability. The product prototype aims to fostering the aforementioned pillars. Students present the final product to the entire class during the final week of the semester. The project and presentation are assessed using the rubric presented in Table 1.The assessment rubric for the final project is presented in Table 1**.** The assessment results for the final project for spring 2016 are presented in Table 2.

Table 1: Measurement rubric for TCGT 1530 final project

Rubric for the Assessment of TCGT 1530 Final Project Presentations						
Group:_____ Activity Evaluated:_____ Evaluator's Name:_____ Date:_____						
Evaluator is (circle one): Course Instructor Student Visiting Faculty Visitor from Industry Other Visitor						
Desired Outcomes	**1 – Below Expectations**	**2 – Progressing to Criteria**	**3 – Meets Criteria**	**4- Exceeds Criteria**	**5 – Far Exceeds Criteria**	**Points**
Organization	Presenters are not prepared.	Presentation is very confusing and unclear. Listeners cannot follow.	Effort required by listeners to follow the presentation. Organization not well thought out.	Presentation is generally clear.	Presentation is clear and logical. Technical points are well made.	
Delivery	Speaker cannot be heard or understood. Presentation is too short or long.	Information is read from a script or directly from the screen. Poor posture.	Pace is too fast or slow.	Reasonable pace and style. Needs some additional work.	Planned conversation with the audience, paced for understanding. Enjoyable presentation	

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Appropriate 'Technical' Content (Addressing the three pillars of sustainability namely: **Environmental, Social and Economic**)	Information is so inaccurate that listener cannot depend on the content.	Enough errors made to be distracting. Confidence in the work begins to be questioned.	No significant errors made. Listeners recognize errors as a result of oversight or nervousness.	No significant errors made. Presenter catches errors and corrects them in time.	No apparent errors. Purpose, method, results, and conclusions clearly stated.	
Ability to Answer Questions	Avoids audience interaction.	Not sure of answers, or answers incorrectly.	Unsure of themselves at first, but answer correctly some questions.	Unsure of themselves at first, but ultimately answer the questions.	Answers questions directly and accurately. Interacts well with students.	
Balanced and Effective Teamwork	Only one member responsible for most of the presentation or remaining members do not participate.	Inappropriate distribution of effort. Approximately, half of the members responsible for most of the presentation.	All members participate, but one or more members dominate.	Balanced participation, but it shows some lack of professionalism.	Well balanced and organized participation showing professionalism.	

All student projects are assessed. For instance during Spring 2016, TCGT 1530 was comprised of about 107 students (thus, n=107). This is the only section of TCGT 1530 being taught, thus there is only one instructor. A target score of 3/5 is assigned to each component of assessment of the rubric due to the fact that this corresponds to a letter grade of 'B'. Given the fact that most students in this class are non-technical majors, a score of 3 on a 5 point scale is quite stringent.

Table 2 presents the results of the assessment. Students' projects for 107 students were assessed using the rubric that was presented in table 1.

Table 2: Assessment scores for TCGT 1530 final project for Spring 2016

	Organization	**Delivery**	**Technical Content**	**Ability to Answer Questions**	**Teamwork**
R.A	5	4	5	5	5
I.S	5	4	5	5	5
D.J	5	4	5	5	5
E.B	4	4	5	5	5
H.H	4	4	5	5	5
C.S	4	4	5	5	5
A.C	4	4	5	5	5
E.M	5	5	5	5	4
A.M	5	5	5	5	4
S.W	5	5	5	5	4
R.E	5	5	5	5	4
B.R	4	4	5	4	5
C.C	4	4	5	4	5
M.S	4	4	5	4	5
S.F	4	4	5	4	5
E.D	4	4	5	4	5

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L.V	5	5	5	4	4
K.H	5	5	5	4	4
T.S	5	5	5	4	4
K	5	5	5	4	4
C.W	5	5	5	4	4
A.H	4	5	5	5	4
C.L	4	5	5	5	4
M.C	4	5	5	5	4
B.E	4	5	5	5	4
A.K	5	5	5	5	4
E.K	5	5	5	5	4
C.L	5	5	5	5	4
C.K	4	5	5	4	5
C.B	4	5	5	4	5
B.S	4	5	5	4	5
A.W	5	5	5	4	5
A.T	5	5	5	4	5
A.F	5	5	5	4	5
C.W	4	4	5	4	4
J.R	4	4	5	4	4
C.S	4	4	5	4	4
I.S	4	4	5	4	4
G.C	5	4	4	5	4
A.J	5	4	4	5	4
M.B	5	4	4	5	4
S.J	5	4	4	5	4
J.C	5	4	4	5	4
H.H	4	4	4	4	0
C.C	4	4	3	3	0
M.B	3	3	2	2	0
J.M	4	4	4	5	0
A.O	4	3	3	4	0
L.B	4	3	4	4	0
R.F	3	3	4	3	3
K.B	3	3	4	3	3
L.P	3	3	4	3	3
S.M	3	3	3	3	3
P.K	3	3	3	3	3
K.S	3	3	2	3	5
D.H	3	3	3	4	4
C.R	3	3	3	4	4

B.T	3	3	3	4	4
J.B	4	4	4	4	5
J.B	4	4	4	4	4
K.F	3	3	4	4	4
H.S	3	3	4	4	4
D.B	4	3	4	4	4
R.G	4	3	4	4	4
A.A	3	4	3	3	4
R.F	3	4	3	3	4
J.Q	3	4	3	3	3
M.O	3	4	3	3	3
E.H	3	4	3	3	3
K.D	3	4	3	3	3
R.P	5	5	5	5	5
T.L	5	5	5	5	5
M.B	3	3	4	5	5
A.B	3	3	4	5	5
E.H	3	3	4	5	5
K.M	4	4	5	5	5
A.T	4	4	5	5	5
H.C	4	4	5	5	5
D.B	4	4	5	5	5
S.S	4	4	5	5	5
T.B	5	4	5	5	5
N.N	5	4	5	5	5
M.J	5	4	5	5	5
V.P	3	4	4	3	5
K.H	3	4	4	3	5
K.J	3	4	4	3	5
H.S	3	3	3	3	4
K.D	3	3	3	3	4
M.H	3	3	3	3	4
K.G	3	3	3	3	4
K.L	4	4	5	4	5
A.P	4	4	5	4	5
M.G	4	4	5	4	5
C.G	4	4	5	4	5
S.S	4	4	5	4	5
C.W	5	5	5	5	5
O.J	5	5	5	5	5
B.C	5	5	5	5	5

ISBN: 97819384965-5-4

R.C	5	5	5	5	5
B.G	4	4	4	3	4
A.T	4	4	4	3	4
J.P	4	4	4	3	4
J.B	4	4	4	3	4
K.B	4	3	4	4	5
K.G	4	3	4	4	5
E.G	4	3	4	4	5
A.P	4	3	4	4	5
	4.037383178	4.009346	4.336448598	4.140186916	4.1495327

As is evident from table 2, the target value of 3 on a 5 point scale was exceeded in all categories of measurement. It has been observed that students are quite enthusiastic about building the final project and can come up with original ideas to try and promote sustainability. It is very clear from the assessment data presented in table 2 that the target value of 3 is exceeded. This finding is very important given the high sample size (n=107). The values are higher for each category of measurement over spring 2015 (See Figure 1).This is especially true in the case of 'teamwork'. This signifies that students in that particular class enjoyed working together as part of a team.

2.2 Course of Action:

2.2.1 Prior Year's Action plans

Implementation of previous year's plan and student learning performance after implementation. More real world examples pertaining to each pillar of sustainability were discussed in class, as states in the action plan for Spring 2015. Examples of past student projects were also presented. The results are clearly evident in terms of an increase in numeric score in all categories of assessment (See figure 1).

2.2.2 Course of Action for next year

Current student projects focus on conceptual feasibility. However, the economics of sustainability is an oft ignored topic that deserves attention. Going forward, it is proposed that the economics of sustainability will be addressed in more detail so as to improve the practical feasibility of projects. Within this realm, topics such as costing, computation of profit margin, classification of different types of cost, buy v/s lease decisions etc will be emphasized.

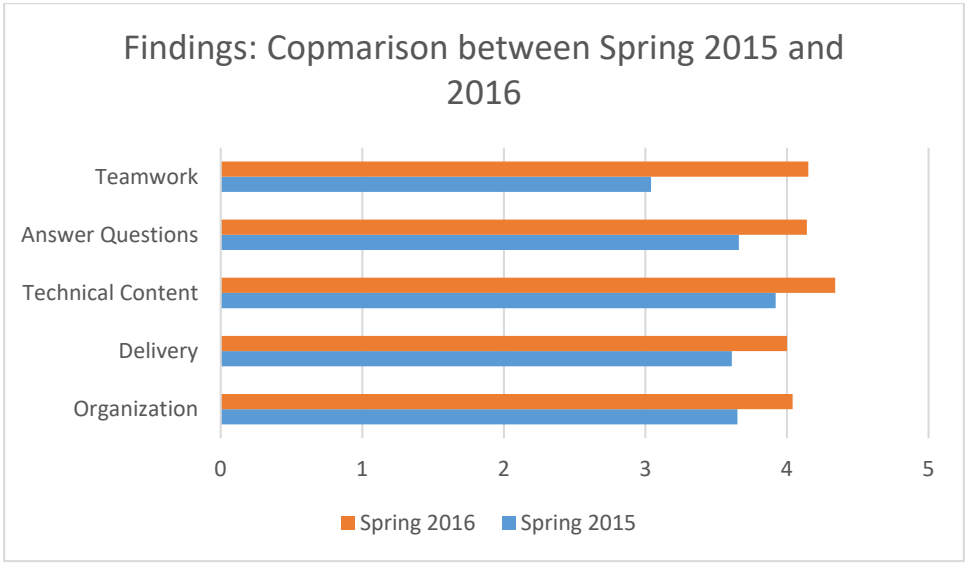

Figure 1: Comparison between Spring 2015 and Spring 2016

3. Conclusion

This paper presented the assessment results of a core class on sustainability. It was observed that student learning has improved significantly in all area of measurement as a result of actions taken in the semester to improve the learning process. As a part of continuous improvement, the economics of sustainability and its various aspects will be emphasized in the future to enahnce the student learning experience even more.

4. References

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