Sustainability, Service-Learning and Student Engagement

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One of the challenges facing the United States educational system is how to inspire more students to be interested in and succeed in STEM (Science, Technology, Engineering and Mathematics) [1]. We are guided in our approach to this issue by remarks William James made in 1899 in his *Talks to Teachers* [2]

> *Any object not interesting in itself may become interesting through becoming associated with an object in which an interest already exists. The two associated objects grow, as it were, together: the interesting portion sheds its quality over the whole; and thus things not interesting in their own right borrow an interest which becomes as real and as strong as that of any natively interesting thing.*

Sustainability is a topic that many young people carry deeply about. Thus if we can link mathematics, a topic perhaps not interesting in its own right to many of our students, with sustainability, students will find mathematics more interesting. Once students' interest is engaged, they are more likely to undertake the challenging intellectual work required to master mathematics. As the model lessons for Mathematics Awareness Month 2013 [3] demonstrate, one can craft classroom lessons that show students the important role that mathematics plays in issues of sustainability while at the same time teaching fundamental mathematical concepts.

The use of service-learning projects [4] involving sustainability is another way to engage student interest in mathematics. Students use their math skills to carry out sustainability-related projects that are of benefit to a community partner, either on or off campus. In my math teaching at the college level, I have employed service-learning projects in several different courses. Student engagement has been high with the students being proud of the positive contributions they have made to furthering sustainability in their community.

Among the projects the students carried out are:

i. Examining the use of trays in the college dining hall. The students estimated that a single tray costs 5 cents to wash, leading to a total annual cost for tray washing of $38,000. Also, by carrying out a weighing of food waste, the students predicted that by "going trayless", the dining hall would cut down on food waste. Following the students' report, the college dining halls have gone trayless.

ii. Estimating how much energy could be saved if college buildings were put into conservation mode during the night, whereby building temperatures would be reduced (in winter) and "off" would become the default setting for all non-emergency lights. Their findings contributed to a shift in the college's operating procedure away from keeping all buildings heated/cooled to a standard temperature range 24 hours per day towards having buildings in conservation

mode for some number of hours during the night.

iii. Carrying out a cost-benefit analysis for a local township on using alternative energy sources for its soon to be built recreational and environmental education center. The students convinced the township commissioners (see Figure 1) to spend an extra $600,000 to install a geothermal (heat pump) heating and cooling system. This system, compared to a traditional system, would have a lower carbon footprint and would save the township $50,000 per year in energy costs. Students helped the township write a successful grant to the state energy department that resulted in a $300,000 award to the township to help pay for the geothermal system.

Figure 1. Math students presenting their findings at the commissioners' meeting.

iv. Examining the pay-back time for replacing the college's compact fluorescent (CF) lighting with more expensive but longer lasting LED bulbs. A key finding was that typically nine different staff members take part in the overall process of replacing a burned out light bulb and that the total cost of all this staff time is about $25 per light bulb. Thus, although the energy savings between a CF and LED bulb are small, the much longer lifetime of the LED bulbs will contribute to significant savings in personnel time (see Figure 2). The college is now in the process of a multiyear conversion of all lighting to LED.

This winter, a retrofit project created the first all-LED dorm on campus. A team of students are now responding to a request from a member of the college's Board of Trustees and are doing a cost-benefit analysis of the retrofit project.

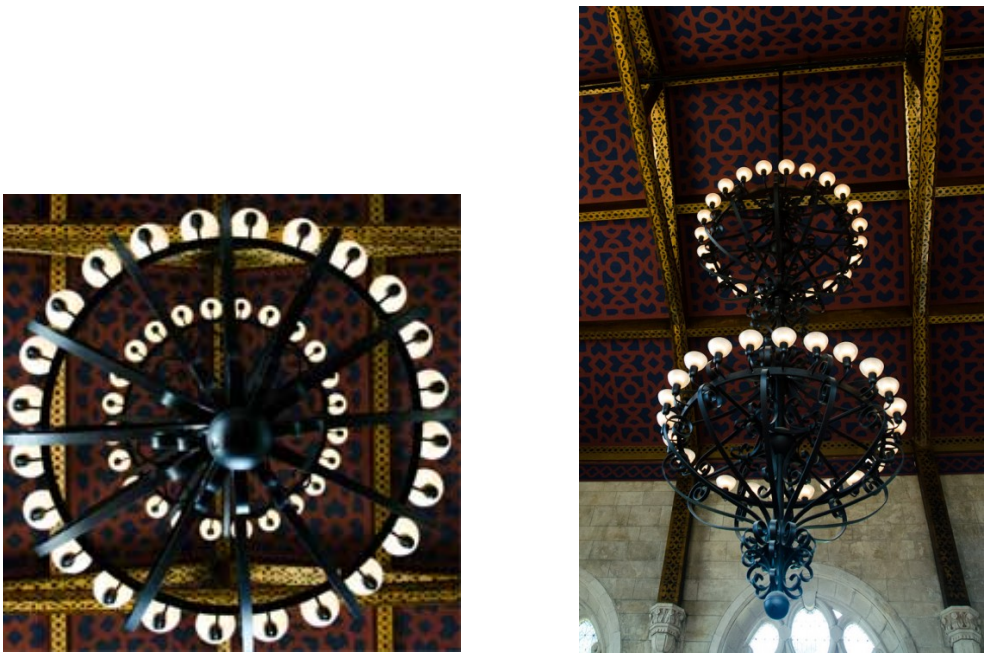

Figure 2. LED bulbs in this difficult to reach chandelier have not needed to be replaced in over a year. Previous generation bulbs burned out within two months [5].

v. Working with the Admissions Office to undertake a cost-benefit analysis of switching to a 100% online admissions system. The students found that presently 98% of applications are received online, but then all the applications are printed out and put into folders. Over 150,000 pages of paper are printed in this process each year and a large amount of staff time is spent in handling the paper materials. On the other hand, the cost of an online admissions system is roughly $250,000. An unexpected finding was that the physical space being used for storing the admission folders had a $25,000 per year opportunity cost that could be realized by repurposing the space. The students recommended going to the electronic system showing that the new system would quickly pay for itself. The college has decided to purchase the online system for the next academic year.

vi. Using a mathematical model of perceived level of safety to determine which roads in the community are safe for bicycle use and whether minor improvements to the roads could increase the number of roads on which one can safely bike. It turned out that the safety rating of some roads could be increased by simply repainting the lines on the edge of the road so as to leave some shoulder space.

vii. Determining whether the college's food composting program should be continued by examining its environmental and economic impacts. This involved comparing the distance traveled in taking food waste to an incinerator versus to the composting site, the costs of two services and the environmental impacts of incineration vs composting. The students determined that as a result of switching food waste out of the trash stream, the number of dumpster pick ups per week at

the dining center fell from five to three. The savings from this reduction paid for cost of the composting program.

viii. The focus on number of dumpster pickups led to a new project: an analysis of the college's entire trash and recycling system to determine if there were opportunities for savings by reducing the number of dumpster pickups or by switching to smaller dumpsters (in progress).

In many of these projects, the community partner was a staff department at the college. The facilities department has become a particularly valuable partner in these student service-learning projects. The staff has a wealth of knowledge around issues of sustainability and have been very eager to work with students to further campus sustainability. At the start, it was challenging to find projects but as I have done it more often, I now find many opportunities for student projects.

The students in these courses showed a high level of engagement, motivation and commitment in carrying out their projects. In the end-of-semester course evaluation survey, they remarked that they enjoyed having a chance to make a difference, be it in their college or the wider community.

"I liked that the projects we worked on were meaningful and that this course was extremely applied in nature. It was nice to do something that affected our college and/or community directly"

" The end results of all the projects were pretty satisfying; it made you feel like you were making a contribution and that you might actually be able to affect something."

In implementing the service learning projects, I gave the students a range of projects to choose from. This approach was based on the service-learning literature [6, 7] which argues for the critical importance of students having a voice in choosing their projects. The passion the students displayed for carrying out their projects confirmed for me the importance of student voice.

Students were surprised at how little advanced math was needed to carry out the projects, commenting that "the math involved in most of these applications was pretty basic" and that "… there were more numbers than mathematics involved in our projects."

This finding is consistent with theories of Quantitative Literacy [8] that stress the difference between applying fairly modest quantitative techniques to real world problems and creating a hierarchy of evermore complicated abstract mathematics. The art of applying the mathematics to a real world setting is a challenging task that needs to be learned in its own right. This skill is not necessarily developed by studying the theoretical side of mathematics. Much of what the students did in their projects could be described as mixing algebra and pre-calculus mathematics together in a stew of "mathematical common sense," a stew that thickens as students gain mathematical maturity. Thus such sustainability oriented service learning projects could be carried out at an introductory

level in a quantitative reasoning course or at an advanced level in a math modeling or senior seminar course. The difference would be the level of support the instructor provides.

While this article focused on college level service learning, the same approach could be used at the K-12 level. The Sustainablity Counts! Energy Challenge [9] provides students with a change to use their math skills to save energy in their schools.

Parts of this article are extracted from my article *Using Sustainability To Incorporate Service-Learning Into A Mathematics Course: A Case Study* that will appear in the PRIMUS Special Issue on Service Learning, in press.

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