Student Inquiries into Neglected Research for a Sustainable Society: Communication and Application

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Student Inquiries Into Neglected Research For A Sustainable Society

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Student Inquiries Into Neglected Research For A Sustainable Society

Abstract

By applying the interdisciplinary approach of Science, Technology & Society, students can solve often-neglected research problems of shifting society's operation towards a sustainable state. A recent Penn State University student research report entitled "The Mueller Report: Moving from Sustainability Indicators to Sustainability Action", contained a detailed ecological analysis of one campus building and addressed methods to optimize its ecological performance in terms of sustainability by utilizing both behavioral and technological improvements. This paper analyzes the factors that affected the successful implementation of sustainable practices generated by student research: i) choosing a receptive primary audience, ii) establishing interpersonal relationships with decision makers, iii) saturating the local media, iv) making sustainability convenient, and v) demonstrating fiscal responsibility.

Keywords: sustainable, self-directed learning, active citizenship

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Introduction

As current unsustainable consumption patterns continue to negatively impact the global environment (Meadows et. al, 1987; Brown et al, 1991; Rees, 1996) and human health (Robertson, 2001), there is a clear need to direct society towards sustainability (Good and Daly, 1996). The concept of ‘sustainability’ is often misconceived because it used in many contexts (Filho, 2000). But as Daly (1991) notes, the ambiguity surrounding sustainability is not all bad insofar as it “has allowed considerable consensus to evolve in support of the main idea that it is both morally and economically wrong to treat the world as a business in liquidation” (248). Given the existence of this now considerable consensus, more specific definitions may be useful for translating intent into deed. Definitions of sustainability generally encapsulate some version of that found in the World Commission on Environment and Development (WECD, 1987), where sustainable development is “development that meets the needs and aspirations of the present without compromising the ability of future generations to meet their own needs” (43). More recent definitions insist that natural capital (Hawken, et al, 1999), or the total capital stock over time (Barbier, et al., 1989; Daly, 1991) be maintained. A sustainable society would be one able to preserve the productive capacity of the global resource base, measured on such indices as biodiversity, natural ecosystems, land quality, freshwater sources, air quality, etc., for an indefinite future (Solow, 1992). Clearly this does not preclude even massive alterations of natural capital, total capital stock or the global resource base, but sustainability does mean, as

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Daily and Ehrlich (1992) point out, that such natural wealth be passed on “undiminished in potential to support future generations” (763).

As the institutions possessing an abundance of environmental expertise, universities have both an opportunity and responsibility to lead in environmental research and model sustainability for the rest of society (Uhl and Anderson, 2001). Although a body of academic work devoted to “greening” academia has begun to amass¹, much of the research conducted at universities is not specifically designed to help resolve society’s problems – like those of environmental decline (Uhl et al., 1996). Universities around the world that do study environmental problems concentrate the vast majority of resources, both mental and economic, on scientific and technological research focused on quantifying sustainability indicators and the frontiers of science and social theories – pushing the envelope on large and complex problems. However, the less grand questions of how to actually implement sustainable practices across a range of contexts, including that of the university institution itself, are often apportioned significantly less resources for inquiry. For example, university scientists have a clear understanding of the physics behind the compact fluorescent light bulb. Yet many university sockets continue to use antiquated, environmentally irresponsible, less efficient, and less economical² incandescent light bulbs. This regretful example is reflected in the greater society where home sockets utilize compact fluorescent light bulbs only sparingly. It is widely assumed that advances in technology will solve environmental problems. However, as Orr states, “Better technology can certainly help, but the crisis is not primarily one of technology. Rather, it is one of mind and hence within

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the minds that develop and use technology” (1996). Although there are many theories and thousands of academic papers dealing with diffusion of innovation and technology transfer³ embodying very degrees of formalization, rarely does the academic institution apply this research reflexively. The “doing it” appears to be left to someone else and thus, is largely left undone.

This neglect of the small questions comes with a price, as the very buildings that make up the physical structure of the universities themselves are enormously inefficient in both material and energy use. The ironies abound: architectural engineers teach in poorly and artificially lit rooms where the eyes of their students wander outside the wasteful single pane windows, the ecology professors’ offices are cleaned with chemicals that are toxic to both themselves and some of the life forms they study, and physicists researching photovoltaic technology run their equipment on electricity generated by obsolete and polluting coal-fired power plants. All of these ironies exact an unnecessarily large, deleterious toll on the environment. In our opinion, these and many similar problems can be adequately addressed if the university takes seriously its sometimes wavering commitment to an interdisciplinary, experience-based (or self-directed) approach *to all* its interconnected functions: educative, research, outreach and administrative. Using an interdisciplinary approach to optimize the university in order to make its operation consistent with the concept of sustainability university students can solve these, and many similar problems.

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This idea has considerable theoretical support in Science, Technology and Society (STS), where STS education fosters critical examination of current science and technology and provides students with the foundations for responsible citizenship (Waks, 1987). This paper analyzes the factors that affected the successful implementation of sustainable practices put forth by Penn State University students in “The Mueller Report: Moving Beyond Sustainability Indicators to Sustainability Action at Penn State” (Green Destiny Council, 2001).

Description of the Mueller Report

The Mueller Report contains an in-depth environmental and economic analysis of one Pennsylvania State University campus building and addresses methods to optimize its ecological performance by utilizing both behavioral and technological improvements. The report began in an attempt to answer a question posed by professor C. Uhl to a Fall 2000 senior-level Biology class: “In what ways is Mueller Building like an ecosystem?” As the concept of treating a building like an ecosystem developed, the class was asked to determine how the environmental impact of the Mueller Building could be reduced by half. Each student chose one input category (e.g., paper, cleaning products, carpeting, etc.) and determined: i) Mueller's annual consumption of that input; ii) the environmental impacts of that consumption; iii) lower-impact alternatives; and iv) ecological-impact (footprint) reductions if alternatives were adopted. This assignment was, thus, a self-directed project utilizing student’s individual interests. This approach encourages in-depth learning across disciplines and capitalizes on students’ personal skills and

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talents to solve real world problems, to demonstrate to the students that their work has value, and thus encourage them to be active, environmentally-conscience citizens in the future (Pearce, 2001).

After the semester was over, students and recent graduates involved with the Penn State Green Destiny Council (GDC), a group that encourages the University to adopt more sustainable practices, amplified and extended the work of the biology students to include not only step-by-step instructions on how the ecological impact of the Mueller Building could be significantly reduced, but also an economic analysis showing how making environmental improvements can reduce the university's operating cost. Their work culminated in the Mueller Report, which expresses the environmental impact of the building using the "ecological footprint" concept developed by Wackernagel and Rees (1995). Following the footprint model, a building's aggregate ecological footprint is a measure of the productive land area needed to sustainably support all the material input and disposal needs of that building. For example, approximately 2,872,000 kWh of electricity were consumed in Mueller Building in 1999 (FASER, 1999). Approximately 1,175 tons of coal were burned to produce this electricity⁴. This coal, a highly compacted plant biomass, is the result of past photosynthesis. If Mueller relied not on fossil biomass, a non-sustainable resource, but, instead, on present-day photosynthesis (i.e. renewable biomass), the building would require a 255 acre "energy plantation" to supply just its electricity needs. There was clearly a need to dramatically reduce the ecological footprint of the Mueller building to reach a sustainable state. The Mueller building is roughly average in terms of

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resource use per unit area at the university (216,155 BTU/ft²) (Donovan, 1999), indicating that the entire university has a long way to go to reach real sustainability. Many buildings on modern university campuses suffer from an aggregate of systemic design failures, poor engineering, and inefficient technologies that waste energy and money. As the Mueller Report demonstrated, the vast majority of natural resource consumption in modern universities is unnecessary to fulfill their education, research, or administrative functions.

The Mueller Report quantifies six main categories of consumption in the Mueller building: energy, water, communication, furnishings/renovation, maintenance, and food.

Virtually all of the energy consumed at the university, and thus in the Mueller Building, is derived from fossil fuels (heating is produced in an on-campus coal-fired steam plant and electricity is purchased from Allegheny Power, a local utility), of which the negative effects of combustion are well known. Mueller's annual electrical and steam consumption in 1999 was 2,872,210 kW-hrs and 7,721 klbs (approximately 8,751 Mbtu), respectively (FASER, 1999). Thus, on average, each one of Mueller's 123 occupants consumed 23,350 kW-hrs of electricity and 62,772 lbs. of steam. By scaling the pollution from a 500MW coal fired power plant⁴, it is found that to provide electricity only for each resident, 9.6 tons of coal were burned, emitting nearly 25 tons of CO₂ (a greenhouse gas contributing to climate change), 134 pounds of SO₂ (a cause of acid rain), and 136 pounds of NO_x (a cause of smog). However, the students found that many technical and behavioral strategies can be utilized to reduce the Mueller building's energy consumption, decrease its environmental impact, improve the work environment of its occupants,

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and save money. Behavioral changes include turning off lights, computers, and printers when not in use and utilizing fractional lighting (when a portion of the light bulbs in a given fixture can be turned on and off independently) when available. Technical improvements can have a larger effect on a building's energy use. The Mueller Report quantified how fossil fuel-based energy for lighting could be cut by 49% by increasing the lighting efficiency and quality. Even larger energy savings can be realized in the heating ventilation and air conditioning (HVAC) system, where making technical upgrades alone could cut the consumption in half, and extra savings could be realized with temperature reductions during the winter, temperature increases during the summer, and temperature changes at night. Overall, the Mueller Report predicts that the electricity consumption in the Mueller building can be decreased by 64%.

The ecological impact due to water consumption could be reduced in the same way. In 1999, the total water consumption in the Mueller building was 883,000 gallons (FASER, 2000). Eighty percent was used in Mueller's laboratories, which could be reduced significantly by replacing single-pass water cooling systems for equipment with circulating water-cooling systems and installing high-efficiency faucets on lab sinks. Most of the faucets currently found in Mueller building have a flow rate of 2.5 gallons per minute (gpm). If Mueller sink fixtures were replaced or upgraded with high-efficiency models (e.g., having a flow rate of < 1.5gpm) sink, water expenditure could be reduced by 40%. The remainder of the water is used in restrooms where low flow faucets could also be installed and waterless urinals and toilets could be utilized to further reduce Mueller's total water consumption by 12.5%.

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Communications (both education and scientific research) is the only output of the Mueller Building that will benefit society if it is increased, although there are still negative ecological impacts associated with it. For example, Mueller Building occupants consume, collectively, approximately 5.3 tons of paper (i.e., over one million sheets) per year (GDC, 2001). Approximately 8.4 acres of temperate forestland (or 2 acres of southern pine plantation) are necessary to supply the pulp for Mueller's annual paper consumption following the calculations of Wackernagel (1995). In Mueller, documents are often printed following standard settings (i.e., 12-point font, 1.25" left-right and 1" top-bottom margins, double spaced, one-sided). Paying attention to the details of font size, column width, and line spacing could result in an overall Mueller paper savings of 46%. According to the Mueller report, each Mueller occupant could decrease personal paper consumption from over 8,000 to approximately 2,700 sheets and in so doing save over 555 gallons of water, about 1.25 million BTUs of energy, approximately 2,650 ft² of forest land, nearly 85 pounds of landfill waste, and almost 800 pounds of CO₂ emissions. The communication ecological footprint can be further improved by encouraging use of computer components that use energy more efficiently (e.g. energy star computers, thin film transistor flat panel displays instead of standard CRTs, laptops instead of desktop computers whenever possible, inkjet printers rather than laser printers, buying remanufactured print cartridges and refilling them within the building, and printing in draft mode).

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The Mueller Report finds that a significant reduction in the ecological impact of the Mueller building is also possible by purchasing the most environmentally friendly furniture available and channeling unneeded furniture in an environmentally responsible fashion. "Environmentally friendly" furniture has minimal environmental impacts associated with production, use, and disposal. The easiest and most environmentally friendly policy to provide Mueller's approximately 600 pieces of furniture is to reuse old furniture from previous building occupants or to purchase used furniture. Mueller could also have its old furniture refurbished and reduce energy consumption for "new" furniture by 85-95% (Business Outlet, 2001). Finally, Mueller can channel unneeded furniture to Penn State Salvage, where it is subsequently redistributed throughout campus or sold at auctions.

Shrinking or eliminating the use of environmentally destructive and hazardous chemicals associated with cleaning products, pest control chemicals, and landscaping can further reduce the ecological impact of the Mueller building. For example, Mueller could only purchase industrial and institutional cleaners recommended by Green Seal, thus ensuring cleaning agents are from an environmentally-responsible manufacturer that considers the ecological impact of its manufacturing procedures and products (Green Seal, 1999). The Mueller Report also suggests adopting an Integrative Pest Management (IPM) strategy to reduce the amount of hazardous pesticides used in the Mueller building. IPM programs utilize various levels of pest prevention and management beginning with cultural/behavioral modification, physical barriers, biological control, and only when necessary, resorting to "safe" pesticides. Although the Mueller grounds

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are relatively small, energy (in the form of fossil fuel combustion) is required to maintain the grass and shrubs and spread mulch, fertilizers, and pesticides. Changing the design and maintenance practices utilized for the Mueller landscape could reduce the landscaping footprint created by these activities. Transformation of the lawn into gardens planted exclusively with native perennials would result in less fuel usage and less air and noise pollution while increasing biodiversity.

Finally, the students looked at three food categories: pizza, coffee, and cookies. Compared to the other topics covered in the Mueller Report, food would appear trivial because of its relatively small share of a building's overall environmental impact. However, food represents a small everyday product that illustrates the need to look at ecologically superior alternatives. Individually these 'minor' products are inconsequential, but in aggregate they have a measurable environmental impact.

Implementing Sustainable Practices

Having a report that clearly lays out indicators such as the environmental impact of a university is not enough to actually implement improved practices (Cobb and Rixford, 1998; Rude, 2000). This point manifested itself to students after the publication of the first *Indicators Report* (Green Destiny Council, 1998), a comprehensive analysis of the operation of Penn State University in terms of sustainability indicators, which resulted in negligible changes to university policy and operations. What happens before the final report is written and released will often

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determine the use of the evaluations (Stalford, 1987). Whereas in traditional academic research the report marks the end of inquiry, as Rudd (2000) notes, using the example of the Union of Concerned Scientists, effective reports must be developed with an orientation to future action in concert with other strategies and domains of activity (272). The Mueller Report was able to make considerable impact on moving the university towards sustainable practices. Five factors that effected student success as measured by actual implementation of sustainable practices due to the Mueller Report are: i) choosing a receptive primary audience, ii) establishing interpersonal relationships with decision makers, iii) saturating the local media, iv) making sustainability convenient, and v) demonstrating fiscal responsibility.

1. Choosing a Receptive Primary Audience.

Biologists, and in particular ecologists, are frontline observers of humanity's negative effects on the environment because of the subjects they research and teach. Some of the very species and ecosystems that they are studying are in danger of extinction. The rate of species extinction has spiked sharply in the last few decades (Wilson, 1992; Ayres, 2000). Only a small fraction of the planet's species has been catalogued, yet approximately 34,000 of the known species of plants are now approaching extinction (World Conservation Union, 1998). A survey by The American Museum of Natural History found that a large majority of the scientists surveyed believe that during the next 30 years, one of every five species alive today will become extinct, with a third of those scientists predicting that as many as half of all species will die out in

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that time (1998). The consensus among those who study life is that the fastest mass extinction in the planet's history is underway. Those who have enough of a concern and appreciation for the complexity and intricacy of life systems to dedicate their careers to study them are much more likely to make changes in their daily lives in order to increase the probability of the survival of all life and thus sustainability. The Mueller Report provided the biologists who use the Mueller Building the opportunity to join their knowledge of life with concrete actions that respect and nurture life. These experts in the study of life could act as "trendsetters" for other academic departments that may be less open to the behavioral changes necessary to institute sustainable practices campus wide.

This strategy of targeting a receptive audience first proved to be enormously successful. When collecting the initial data for the Mueller Report, student researchers found the biologists of the Mueller Building to be extremely helpful in not only providing answers to questions (e.g. if they recycle, if they turn off their computers when not in use, how often they use the restroom, etc.), but the professors would also offer suggestions for further improving the sustainability of the building. In addition, several Mueller occupants agreed to preview drafts of the Mueller Report to offer critiques and suggestions. Opening the process of inquiry to the intended audience prior to the public release of such a report has been shown to be beneficial (Dearing, Meyer, and Kazmeirczack, 1994). Although initially concerned that the report may put them "under the microscope," the biologists were enthusiastic participants in the process of constructing and adopting the report. The Biology Department proudly displayed a summary of

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the Mueller Report on their web page as the “news of the month”, and formed a committee of professors to look at making specific changes to the aspects of the Mueller Building under departmental control. For example, they are considering using the Mueller grounds as an educational tool for their courses concerning indigenous species. Also many small behavioral changes have already taken place, such as the initiation of a viewgraph-recycling program. Within a month of the release, many people in the Biology Department had read the report and voiced strong and enthusiastic support for the project. The department head was willing to mandate some improvements within the department (e.g. Purchase of flat panel TFT screens rather than CRTs for the monitors the department purchases) and to make departmental “suggestions” for purchases under the discretion of the faculty.

This strategy of choosing a receptive audience continues as another student group has begun a study of a second University building, home of the environmental engineers. An initial inquiry of occupants indicates that they are even more outspoken than the biologists on the need for increasing the efficiency of university building systems. With the experience and calculations provided by the Mueller Report, each additional ecological analysis of university buildings becomes easier and allows the students to expand the scope of their studies to become more comprehensive. For example, rather than “just doing another Mueller Report” the new study will include major sections on indoor air quality and the “learning environment”.

2. Establishing Interpersonal Relationships with Decision Makers

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Regardless of the rigor of the ecological accounting in the Mueller Report, sustainable practices would not be instituted unless individuals were convinced that the sustainable path was the right one to follow. Yet, as Dickson (1984, 2000) explains, problems in the communication of scientific knowledge are a great degree political in nature. In order to convince the appropriate individuals, the biology students began establishing relationships with the building occupants immediately in their data gathering. They maintained those relationships throughout the development of the research by giving occupants the opportunity to interact on the work that culminated in the Mueller Report. At the end of the semester, the students presented their findings to representatives for the building as well as staff responsible for the building's operation from the Office of the Physical Plant (OPP). As members of the GDC took over the project, the relationships with OPP staff and building occupants were maintained in order to ensure the suggestions made in the report remained viable. Drafts of the report were sent not only to building occupants and OPP engineers for technical review, but also to twenty university leaders who were asked to review and comment on the report qualitatively. The unanimously positive endorsements of the report were inspiring for the students and many were included on the back cover of the report as an indication of the university-wide consensus on environmental stewardship. The endorsement of these university leaders also added political weight to the student report. In addition, draft copies were sent to key university administrators to keep them updated on student activities, and to ask for their advice on how to get sustainable improvements implemented in Mueller. In this way, most individuals that have control over the degree of

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sustainability in the Mueller Building came to 'own' the report because of their personal contributions.

The Mueller Report was formally released on a bright sunny afternoon in a large open-air public ceremony on the steps of Old Main⁵. The director of the campus' Environmental Stewardship Strategy (ESS) received the report on behalf of the administration in front of several hundred onlookers (mostly students). The next day, top university officials invited report coordinators to a meeting to discuss the practicality of the recommendations contained in the report. The university administrators were extremely supportive and called a second meeting with OPP, ESS, the biology department, and the GDC in which the details were determined: several hundred thousand dollars are being invested in maintenance of the Mueller Building, it will be continuously commissioned (see section 5), waterless urinals are being tested (including a "urinal hotline" for comments and complaints), laminar flow water faucet aerators are being researched in greater detail, and a class of architecture engineering students will help design and analyze a new standard lighting scheme or "super lighting" in one room of Mueller as demonstration⁶.

3. Saturating the Local Media

Another factor in these successes was the supplementation of interpersonal relationships with a campus wide education program utilizing local media. Both of the Earth Summits (Rio de Janeiro in 1992 and New York in 1997), the World Commission on Environment and

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Development in 1987, and the United Nations Conference on Environment and Development in 1992 emphasized the role that education can play as an agent of environmental change. Yet, one of the biggest problems faced in adoption of sustainable practices remains the dissemination of knowledge about environmental problems to the public (Brundtland, 1998). Only a few people read most academic papers (where environmental decline is discussed in detail), and indicators reports are read by maybe a few more (where environmental decline is quantified on a small scale), but for the most part these go unnoticed by the majority of a university's community. In order to have the Mueller Building improved, it was necessary to obtain popular support. More importantly, if sustainability was going to spread to the rest of the university, the majority of the university community needed to be informed.

The Mueller Report media campaign formally began when the public information officer of the Eberly College of Science sent a news release to local and university news organizations on the official release of the report. The official news release resulted in several newspaper articles, a local television appearance, and a piece in the Penn State newswire that goes out to 20,000 subscribers. In order for sustainability to remain a salient issue, a senior level class of communications students was asked to outline an information system centered on the report. The effectiveness of information systems operating in a learning context depend largely on the following (Moxen and McCulloch, 1999): i) the degree to which adequate sources of environmental information are available; ii) the ability of disseminating organizations to access these sources, iii) the degree to which disseminating organizations are aware of the information

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needs of their client groups; and iv) the willingness of organizations to dedicate resources to the activity of information dissemination. Based on these four criteria, the media campaign publicizing the Mueller Report was well positioned for success. First, adequate environmental information concerning the topic in question was comprehensively covered in the Mueller Report itself. Second, this information was made available to the disseminating organization (the communications students) through a seminar summarizing the key technical points, a fact sheet, and online or hard copies of the report. Third, the client group was largely made up of students -- so the disseminating organization was targeting their peers. Finally, the students were willing to dedicate considerable resources to the activity of information dissemination for the following: i) to acquire a high academic grade, ii) develop a professional portfolio for use in procurement of future employment, and iii) to help conserve the environment.

The students utilized several communication theories from class as a guide to developing an effective information campaign. The first goal was to gain attention and interest for the report itself: the majority of campus was "chalked" (often in non-conventional yet more effective ways e.g. on the vertical surfaces of steps) and bulletin boards were covered with Mueller information flyers, flyer notices were sent to graduate list-servs and email announcements to lists and leaders of all the relevant campus groups (e.g. the 1800 subscribers of the Penn State Catholic Community E-bulletin, Center of Sustainability, and all the Penn State sororities, etc.), clubs (e.g. Eco-Action, the Green Design Team, Environmental Economics Club, etc.), and courses (e.g. Energy and Society, Environmental Policy, etc.), and a presentation was made to the STS

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Interest House. For the official release, the students blanketed the campus with Mueller information: sidewalks and classroom blackboards were chalked, Old Main lawn had signs placed along the walk way, lollipops were handed out, signs were carried and “leaf women” attracted passersby to the Mueller release. All of this work resulted in a total of 6 articles in the Collegian (the student newspaper), including an editorial staff endorsement and several op-eds. However, it has been known for some time that effective media campaigns must include significant interpersonal contact (Lazarsfeld and Merton, 1948; Rogers, 1995). To this end, the Mueller Report was also used as course material in an expanding array of courses (e.g. STS497D Sustainable Living, Eng 202C Technical Writing, and STS100 the Ascent of Humanity) and the subject of several information seminars. Information centered on the report also percolated off of the campus where it was featured in GreenClips, the Sustainable Building Design News Digest; Second Nature, a nonprofit organization working to integrate environmental sustainability into curriculum and campus operating practices; The Pennsylvania Business Central, and Footprint News. The final indication that the Mueller Report had saturated the local media was when at the free campus movies, a Mueller Report Preview played during finals week. Presumably, this media saturation led to popular support that assisted the adoption of sustainable practices outlined in the Mueller Report.

4. Making Sustainability Convenient

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As the value of time has increased in today's fast paced society, convenience often outweighs other variables, such as cost in decision making (Messinger and Narasimhan, 1997). The Mueller Report called for considerable changes on the part of everyone involved in the building – from the janitors to the professors; and thus, convenience was paramount for adoption of sustainable practices. The Mueller Report not only quantified the environmental impact of the Mueller building but also methods to reduce that impact. These methods were not left as abstract concepts, but rather they were spelled out with concrete examples to make it easy for the non-specialist to both understand and easily institute. For example, phone numbers and web addresses of several competing companies which supply environmentally superior products or services were included in the footnotes in order to reduce the inconvenience of changing purchasing practices. Prices were included often and for those improvements that initially cost more but eventually pay for themselves (i.e. in energy savings), payback periods were calculated. This made some of the policy suggestions easy to institute immediately because Penn State follows a policy dictating investment in environmental improvements that pay for themselves in less than five years.

5. Demonstrating Fiscal Responsibility

Although it remains unpopular to discuss, for some time now universities have been undergoing a “corporatization”, where education is the product being manufactured (Weiss, 1965). In accordance with other types of corporations, a strict adherence to a bottom line ethic

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has become necessary for universities to maintain competitiveness in the higher education market. Thus, one of the strongest techniques for encouraging sustainable practices in the university setting is showing that they will save money. The least complicated method of reducing the ecological footprint of a system while saving money is to reduce the amount of a given resource necessary to accomplish a given function. This is best illustrated with energy. Penn State pays \$0.0233 per kW-hr and \$7.58 per peak kVA for electricity, and \$9.76 per 1,000 lbs of steam (thermal energy). Mueller's HVAC system could use significantly less energy if it underwent the "continuous commissioning" process developed by the Energy Systems Laboratory from Texas A&M University (ESL, 2001). Continuous commissioning optimizes the operation of the existing building systems for comfort, energy use, air quality, and operational costs. As an example of the economical prudence of continuous commissioning, consider the Material Research Institute (MRI) building that recently underwent the continuous commissioning process at Penn State. By comparing utility meter readings for 1998-99 against readings for 1997-98, it is estimated that the MRI building reduced electrical consumption by approximately 12%, and reduced its natural gas consumption by approximately 38% in Phase I of the continuous commissioning process (Donovan, 2001). This amounts to ~\$83,970 in 1997-98 energy costs. Since the expenses for the Phase I project were \$88,920, this results in a simple payback of just over one year (1.06) (Donovan, 2001). Penn State will thus continue to reap nearly \$84,000 a year in energy savings from its investment in the continuous commissioning

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process of this single building over the life of the process. Similar results would be expected in the Mueller Building, which is undergoing continuous commissioning in 2003.

The Mueller Report provides case studies that show for a given function (e.g. lighting, paper, pest control, etc.), it is possible to save money and reduce ecological impact by: reducing resource consumption, decreasing waste products, purchasing environmentally responsible products, channeling used products in an environmentally responsible way, and reducing/eliminating environmentally destructive and health threatening products. In the cases where some improvements cost less and some cost more, "cost coupling" can be utilized -- savings from one economically beneficial product can be used to pay for the additional cost of one that may cost more. These fiscal savings can be formidable. For example, if both behavioral and technical improvements are made to reduce the Mueller building's electricity use, over 1,950 tons of CO₂ (a greenhouse gas) emissions would be eliminated and over \$45,000 would be saved per year. If these results are extrapolated over the University Park campus as a whole, millions of dollars could be saved each year in the university's operational costs. Neither the Mueller building nor Penn State are anomalies. The implications of the economic and environmental savings to other universities and indeed all buildings are tremendous.

Conclusion

The very fact that it was necessary to write a Mueller Report and that ecological impact reductions could be as great as 50% in an average university building gives strong evidence that

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applied sustainability research has been largely overlooked. The impressive magnitude of the potential environmental and economic savings and the wide array of products and services consumed in the university setting offer an enormous and rich opportunity for student researchers to help move society towards a more sustainable state. The fact that students largely completed the work (using the conceptual tools of life cycle analyses and ecological footprint analyses) that went into the Mueller Report demonstrated that undergraduate students are capable of such research if guided appropriately. The five strategies utilized by the students that were instrumental to the adoption of their recommendations for sustainable practices were: i) choosing a receptive primary audience, ii) establishing interpersonal relationships with decision makers, iii) saturating the local media, iv) making sustainability convenient, and v) demonstrating fiscal responsibility.

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Notes:

1. See for example: Creighton, S. H. (1998). *Greening the ivory tower: improving the environmental track record of universities, colleges and other institutions*, Cambridge,

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MA: MIT Press; ed. Collett, J. and Karakashian, S. (1996), *Greening the College Curriculum: A guide to Environmental Teaching in the Liberal Arts*, Washington D.C.: Island Press; and The International Journal for Sustainability in Higher Education that started publishing in 2000.

2. A compact fluorescent light (CFL) bulb with similar illumination output to a typical 100W incandescent bulb utilizes only 25W. The CFL bulb lasts 10,000 hours compared to the incandescent of 750 hours. Thus, 13.3 incandescent bulbs are needed to match a single CFL. At prices listed on Home Depot's website the purchase cost for bulbs lasting 10,000 hours comes out on the side of the incandescent (\$4.57) vs \$16.94 for the CFL. However, when the cost of electricity (\$0.0615 per kW-hr in State College) to run the bulb for 10,000 hours is included, the CFL costs much less \$32.32 compared to \$66.07 for the incandescent. Thus purchasing a single CFL will save the State College homeowner \$33.75 over the life of the bulb.
3. See for example the well-known models discussed in Rogers, E.M. (1995) *Diffusion of Innovations* 4th ed., New York, Free Press.
4. Coal needed and pollution emitted for a given amount of electricity was calculated from scaling to a 500 megawatt coal plant produces 3.5 billion kilowatt-hours per year, enough to power a city of about 140,000 people. (UCS, 2000). Available at: www.ucsusa.org/energy/brief.coal.html

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5. Old Main is the head administration building at University Park. Holding the public release of the report on its steps added institutional legitimacy to the event.
6. Lane (2000) provides compelling evidence that high-profile demonstration projects are well received and effectively advertise a new technology.

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