Dalhousie University

The Extent of Sustainable Education in the Engineering Faculty at Dalhousie University

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Campus as a Living Lab: Final Report

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Executive Summary

Since we did not get 55 out of 56 surveys returned which is a 98.2% return rate (which is an impossibly high number) our findings are not with in the 95% confidence interval thus our findings are inconclusive.

What our data has shown us is that professors only seem 33.3% confidant that there is a “good amount” of sustainable education present in undergraduate engineering classrooms, and 33.4% of professors are unsure if what they are, or others are teaching constitutes as a “fair amount” of environmentally sustainable education.

There also seemed to be some overlap with sustainable topics which are discussed in the classrooms, such as pollution and sustainable living, this is a good start but begins to show the lack of vast sustainable knowledge being taught. Thus, what the engineering students are learning about sustainable education is not a sufficient- enough amount to be considered a good amount of sustainable knowledge.

The majority of professors at 42.9% were against the addition of another first year engineering course option that a student could choose which specifically focuses on sustainable building which can be counted towards their degree, and incorporates environmental and sustainable engineering concepts. 14.2% of professors answered to this question that it is should be an option, and 42.9% said adding this type of coarse option is worth considering.

The means for the answers to each question on our surveys resulted in large standard deviations, meaning there was no general correlation or consensus on the professors answers about how much sustainable education already exists in the classrooms and if this type of education deserves to be increased.

Our team of environmental scientists had found it difficult to get the information we needed out of the engineering professors from Dalhousie University, as well as get them to complete our surveys which was to our disappointment after relentless reminders.

Consequently we feel our line of research would benefit from further research, to one day be able to integrate an increased amount of sustainable education into engineering classrooms.

Further recommendations would be to talk to the upper year Dalhousie Engineering students themselves to ask them how much sustainable education they feel they are learning from the material incorporated into their lower level classes. This would give us more of an insight into the type of information being presented in classrooms from a different perspective and could further assist out research in moving forward towards larger results which can be more conclusive regarding the amount of sustainable education being taught in undergraduate engineering classrooms today.

Our hope is to understand the type of sustainable education being taught and have professors understand the importance of this type of education and help increase its relevance in classrooms in the future.

Introduction

Background and Rationale

Our decision to focus on engineers in our study was influenced as we viewed the faculty as possessing a great potential to yield beneficial results from the integration of sustainability concepts into required courses. Engineers represents one of many multidimensional professions that directly influences and guides numerous choices we make in society regarding the development of infrastructure and new technologies. Some contributions to society that have come from the influences of engineering are marked by the advancement of communication, transportation, productivity and so on (Engineering, 2014). The work of engineers does not just center on machines, designs or circuit boards, but also involve engaging in negotiations and making final decisions and ethical judgments that can greatly affect the environment (Lawlor, 2013). We understand that students pursing a degree in engineering regardless of their specific discipline choice, upon graduation will go on to implement what they have learned into solving real world problems. We see the potential that engineers possess to improve the living standards for society, and by focusing on this in our pilot study we can have a better chance in integrating sustainability concepts into required courses in all facilities.

According to United Nations, the world's population is projected to reach about 9 billion people by the year 2050, a near increase of 2 billion people in less than half a century. Understanding that we live in a finite world with limited resources and an ever expanding population, we look to engineers to invent a solution to the problems of tomorrow. It has been noted in the literature that engineers cannot rely only on their traditional top-down technocratic approach to cope with the challenges of sustainable development (Aurandt, Borchers, Lynch-Caris, & Hoff, 2012). Presently engineers are finding it difficult to satisfy the needs of our population while simultaneously trying to preserve the carrying capacity of our ecosystem and biological and cultural diversity (National Academy of Engineering, 2012).

Environmental and sustainability issues will continue grow in importance and become even more of a pressing issue with the addition of 2 billon people on the planet. Observing our history of progress through time we see that humans for a long time have been steadily transforming the natural environment to suit our needs. Human activates such as forestry, industry, transportation and agriculture are vital to our survival but also have a negative impact on the environment (Goudie, 1997). This dilemma of we are living in has been described to us as the tragedy or problem of the common. Originally written by Garrett Hardin as his first attempt at an interdisciplinary analyses, led to an essay that looked at the idea that a common or shared resources with no market value will inevitably be overused and destroyed (Hardin, 1998). Looking at past civilizations, Hardin's theory is carried out on Easter Island with the Polynesians who after centuries of forestry and statue building led themselves to deforestation of the island which ultimately led to their collapse in the 17th century (Wright, 2006). Understanding that we face a problem that is associated with overpopulation and resource depletion, we identify the need to seek environmental and sustainability education for professions that deal with addressing this issue (Aurandt et al., 2012).

“The development of ecological understanding is not simply another subject to be learnt but a fundamental change in the way we view the world.”- John Lyle 1994

Throughout history, education has been a significant part of society development as the changing factor into a civilization. The UN conference on the Human Environment held in 1972 in Stockholm, pointed to the importance of ‘environmental education (EE) and later ‘education for sustainable development’ (ESD). The UN world summit on Sustainable Development also notes that much of the current education falls short of that is required, and calls for a deeper, and a more ambitious way of thinking about education (Sterling, 2001). Integrating sustainability concepts into the context of higher education aims to address the importance of the natural environment to students and to advance the ideas of resource preservation (Shuttleworth, 2013). Looking at higher education in Atlantic Canada we see sustainability is becoming an increasingly important issue as many Canadian universities and colleges have committed to signing the Talloires Declaration University Leaders for a Sustainable Future (Beringer, Wright, & Malone, 2008). The Talloires Declaration is a ten point action plan for incorporating sustainability and environmental literacy into teaching, research, operations and outreach to colleges and universities. The declaration has been signed by over 350 university presidents and chancellors in over 40 countries (Talloires Declaration, 2001).

As times are changing the need for all professionals to adopt a new mindset towards sustainable development is of the most importance. Having placed focused on engineers; we are looking at the feasibility of integrating environmental and sustainability concepts into required courses. We aim to equip engineers with the necessary foundation in sustainable and environmental education to create innovative solutions to future problems. Today, major problems are often a compilation of into connected issues that cannot be solved by one discipline (Mulder, 2004). Engineers are involved in every aspect of environmental protections and pollution prevention as they are responsible for designing, installing, operating, and regulating facilities throughout the world (Roisman, 1995). In the future new strategies must be further integrated to include environmental and sustainable concepts into project designs and policies.

Looking at Dalhousie’s courses for engineering we attempt to identify to what extent is sustainable material already being taught in engineering. We believe mandatory courses can benefit engineers by providing addition and useful information into its curriculum. Biology 1030 for engineers gives students a basic understanding of cell structure and function, genetics, ecology, and the relationships between living systems and man-made environment, and relevance of biology to industrial and engineering applications (Engineering, 2014). In observing mandatory courses such as and similar to Bio 1030, we want to identify the extent to which sustainable concepts are being incorporated to both benefit and challenge engineers to consider sustainable solutions to real world issues. In conducting this study we aim to understand what it would take to integrate such invaluable methods of thinking into the beginners’ course for engineers.

Objectives

Our team of environmentalists at Dalhousie University believe environmental education is vital when it comes to changing how our society sees the world. Environmental education is an important tool in creating priorities for sustainability. We define sustainability to be how biological systems remain diverse and productive, while sustainable thinking makes sure any new addition into our biosphere does not alter or damage the natural environment but helps keep it healthy. New practices should be able to sustain for an extended period of time with minimal damaging consequences to the natural and build environment (Setting a Policy for Sustainability: The Importance of Measurement, 2015). Universities are designed for students to gain an education, which helps them better understand the world and contribute to it. So our team wanted to find out how much sustainability education exists in undergraduate engineering university classrooms. Since it is difficult to target an entire student body we have limited our focus group to engineering students, and targeting questions regarding sustainable education at the faculty of engineering professors.

Engineers are our future developers, the career list for this degree extends to land developer, production supervisor, structural design consultant, continuous improvement engineer, pollution control specialist, health and safety supervisor, economic analyst, air craft design engineer and the list continues (Dalhousie Engineering Academic Timetable 2014/2105). These types of professions are vital in society's functions and also have a large effect on our natural and build environments. All human activity has a consequence, being good or bad. If professional people had a stronger fundamental understanding of our environment and resource constraints, the delicacy of nature's balance and become more aware of the validity of the ecological crisis we have on our hands we could be on our way to a more sustainable world (Influence of an Environmental Studies Course on Attitudes of Undergraduates at an Engineering University, 2104). We want future engineers driven to develop sustainable projects. When one is aware of the delicate interconnectedness between humans and the natural environment these concepts will be considered when developing project guidelines. We think the issue is not that people don't care about creating a sustainable environment it is that they do not have the tools to understand why it is important to do so and how to go about doing it.

We want to provide these tools through education. The purpose of our study is to determine how much environmentally sustainable education is being expressed in the engineering classrooms at Dalhousie University. Some engineering courses already talk about natural components and sustainable materials so our team thought this faculty would have a smooth integration into environmental education.

We have created a survey and a short questionnaire that we will hand out to the Dalhousie university engineering professors which will help us gather the data in order to asses how much sustainable education is already stressed in undergraduate classrooms.

It is important to have basic environmental sustainability knowledge at a fundamental university level because it can lead to students making decisions to choose future areas of study or careers that help improve our natural and built environment's current state of existence, and lead students down a path of sustainable thinking.

We deem environmental education necessary and are choosing to begin with engineering students because they are relevant, forward thinking and potential future developers and leaders in our society.

Methods

Methods Overview

The methods section of this paper aims to clarify the actions we took towards our study in determining the extent to which sustainable education is incorporated into the undergraduate curriculum at Dalhousie University. To pilot our study we focused on evaluating the curriculum in one of the faculty departments at Dalhousie University; observing the level of sustainable education taught in the program. Research was conducted through the use of questionnaires, which aimed to assist us in drawing some correlations and possible conclusions in reference to our research question: To what extent is sustainable education being incorporated into the undergraduate curriculums at Dalhousie University?

A major component of our research that we are reliant upon is the distribution and collection of questionnaires. This study requires that we gather an appropriate amount of respondents with which we can draw on collected data to make inferences and or conclusions towards answering our question. A conclusion was drawn up after much analysis and presented at the Pecha Kucha night of ENVS 3502.

Participant Recruitment

In conducting our pilot study, the decision was made to focus on the undergraduate curriculum of Engineering Students at Dalhousie University. We did not target students to collect data from but instead placed more emphasis on generating feedback from individual professors of the various disciplines in engineering. The population of interest for this study were professors currently teaching within the faculty of Engineering at Dalhousie University (see Appendix 1). The Sampling frame consisted of fifty six (56) professors from six (6) different departments in Engineering Faculty. These Engineering departments were that of: Civil and Resource, Electrical & Computer, Mathematics & internetworking, Industrial, Mechanical, Process & applied Science (PEAS) and Biomedical Engineering. Initially we attempted to extend participation to all professors and request their involvement but in excluding professor emeritus and among other those professors on leave and not currently teaching we have specified our population. The recruitment stage of our research began contacting professors via E-mail (see Appendix 2), briefing them about our intended research of their faculty.

Description of Study Design

Once contact was made through E-mail and the professors had been briefed, we proceeded by attaching copies of our questionnaire (see Appendix 3) to be delivered electronically to professors on the 12th of March 2015. In accordance with our time schedule (see Appendix 4) we had given participants one week to fill out and return completed questionnaires before sending reminder e-mails. In total we sent 5 reminder emails to professors within the span of 20 days.

The questionnaire was split into two parts, and began with an introduction, to ensure that the context of the study was well understood by participants (Wright, 2015). In the first section of the questionnaire we asked the professors to rate on a scale of 0 – 5 which corresponded to; never, very rarely, rarely, occasionally, frequently, very frequently. The second section of the questionnaire was short answer questions aimed to generate free flowing opinionated responses from participants. In the course of our data collection the identity of participants were kept confidential, and only revealing their departments. This information would go forward to assist us in analyzing findings in the study.

Aside from the e-mail responses we received, we also administered hard copies of the questionnaire to sight to two Engineering departments on sexton Campus. Hard copies were placed within professor's mail box and given instructions to find out and return to the department sectary. Hard copies were issued to on three separate occasions and we returned to collect the surveys within a few days' time.

Upon collecting questionnaires, we numbered them and the two sections of the questionnaire were analyzed quantitatively and qualitatively where relevant. The process of collecting completed questionnaires was not very promising and participant involvement was relatively low. We only received 9 completed questionnaires from the 56 we distributed.

Quantitative Analysis

The first section of the questionnaire was be analyzed using quantitative analysis. Based on the results gathered from the rating questions, a score was tallied and inserted into an excel spreadsheet for further analysis. The mean, median, and mode for each question was also calculated to be used with other results in answering our research question.

Qualitative Analysis

In conducting qualitative analysis we decided to use a posteriori context sensitive scheme (Wright, 2015), while following the specific guidelines from Creswell's research design (2014). Our research also including word coding which was carried out on the short answer responses of the questionnaire. See Appendix 5 for our coding methods used. One group member created a simple coding system that followed a set of guidelines such as:

Step 1. Proper organization of collected data into an excel sheet and ready for analysis. This step required that questionnaires be numbered to ensure the confidentiality of the participants, while keeping reference of important data.

Step 2. All questions were read and gave the group member responsible for creating the code, an opportunity to get a general sense of the information, and reflect on its meaning.

Step 3. In this step the data was coded based on some emergent themes within the text, organized into small sections, and made to correlate to words which were represented a category.

Step 4. The final step required the themes and categories to be determined from the completed coding. The data uncovered here went towards constructing some conclusions to our research question as it relates to the entire Engineering faculty as well as the individual departments.

Limitations and Delimitations

Throughout the course of this study there were a few limitations which prevented our group from executing more efficiently with our data collect and analysis. The time frame with which we had to work with and the availability of the participants in question were two factors which may have influenced the limited results of our questionnaire. Considering the study had to be completed within a pre-set timeframe produced some conflict with scheduling professors and collecting feedback. The vast majority of participants showed no real interest in taking part in our study. Most professors ignored our e-mails and turn down our hard copy of the questionnaire due to busy schedules. No averages could be drawn from the data collected because of the ordinal nature of the rating, and we were limited to the mode and median for measures of central tendency. Another limitation included in the research was the availability of the research team in scheduling a common meeting times, which proved to be challenging.

Results

As seen in Figure 1 there is high variability between the means of the average questionnaire response. There is also considerable spread in the Professors' answers within each question. In Table 1 the standard deviations and interquartile range (IQR) for each questionnaire question can be seen. Very few questions had a standard deviation of less then 1. Those questions include 3c, 5c, and 7a. Interestingly 3c was also the lowest rated question on average, while 5c and 7a were the highest rated questions on average.

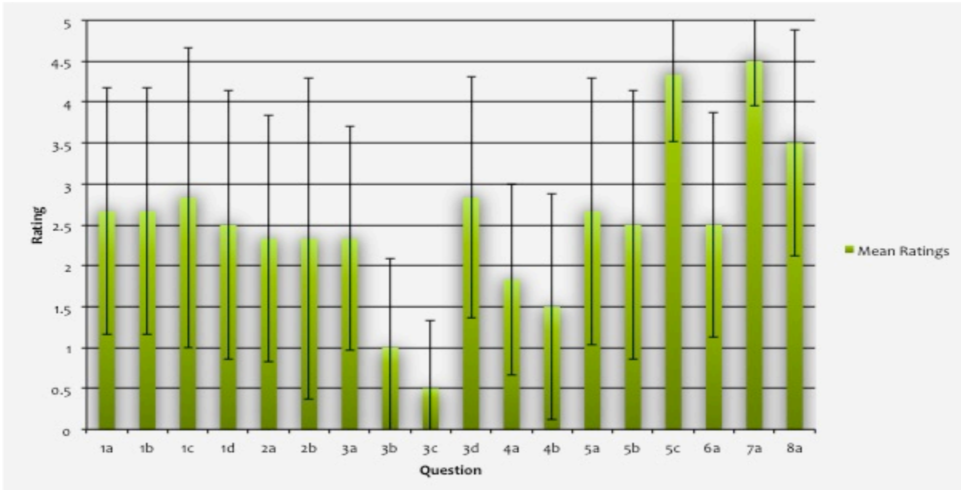

Figure 1 The mean ratings for each question, the error bars represent the standard deviations.

Table 1 Survey questionnaire mean numbered rating, corresponding descriptive rating, and standard deviations. Rating scale: 0=Never, 1=Very rarely, 2=Rarely, 3=Occasionally, 4=Frequently, 5=Very frequently

Question	**Mean**	**Rating Equivalent**	**Standard Dev**	**IQR**
1a	2.666666667	Rarely/Occasionally	1.505545305	2
1b	2.666666667	Rarely/Occasionally	1.505545305	2
1c	2.833333333	Rarely/Occasionally	1.834847859	3
1d	2.5	Rarely/Occasionally	1.643167673	1.5
2a	2.333333333	Rarely/Occasionally	1.505545305	2.5
2b	2.333333333	Rarely/Occasionally	1.966384161	4
3a	2.333333333	Rarely/Occasionally	1.366260102	1.5
3b	1	Very rarely	1.095445115	2
3c	0.5	Never/very rarely	0.836660027	1.5
3d	2.833333333	Rarely/Occasionally	1.471960144	2.5
4a	1.833333333	Very rarely/Rarely	1.169045194	2
4b	1.5	Very rarely/Rarely	1.378404875	3
5a	2.666666667	Rarely/Occasionally	1.632993162	2
5b	2.5	Rarely/Occasionally	1.643167673	3
5c	4.333333333	Frequently/Very frequently	0.816496581	1
6a	2.5	Rarely/Occasionally	1.378404875	1
7a	4.5	Frequently/Very frequently	0.547722558	1
8a	3.5	Occasionally/Frequently	1.378404875	3

As displayed in Figure 2 codes that emerged in the professors' answers include one-third replying that undergraduate engineering students currently receive an acceptable amount of sustainability related material in their program, one-third replying that there is not enough sustainability material taught, and the remaining professors not knowing what the current level is.

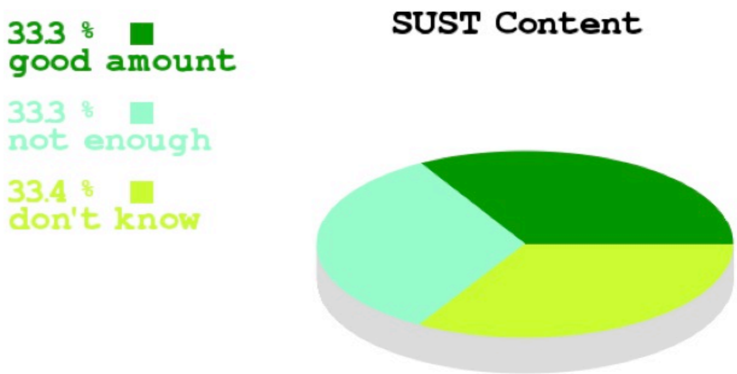

Figure 2 Profs opinions on the current level of understanding undergraduate engineering students will have after completing their degree. Measured in percent of professors whose answer corresponded with the code.

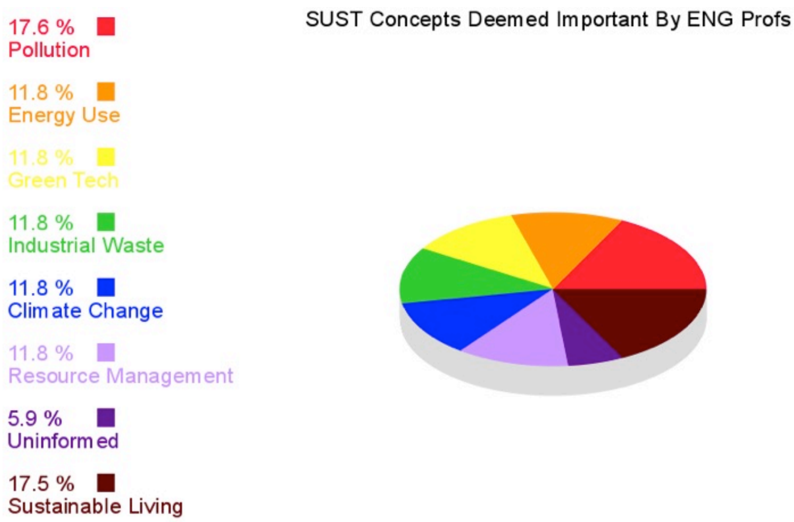

Figure 3 The most common codes which emerged from the Profs answers to what sustainability concepts they believe to be most important, and should be discussed thoroughly. Measured in percent of codes taken from the responses to opinion question 2.

As seen in Figure 3 the codes that emerged from the second opinion question represented a wide range of very important sustainability and environmental issues. Popular issues included pollution, energy use, green technology, industrial waste, climate change, resource management, and sustainable lifestyle. Just under 6% of the answers coded as an uninformed answer.

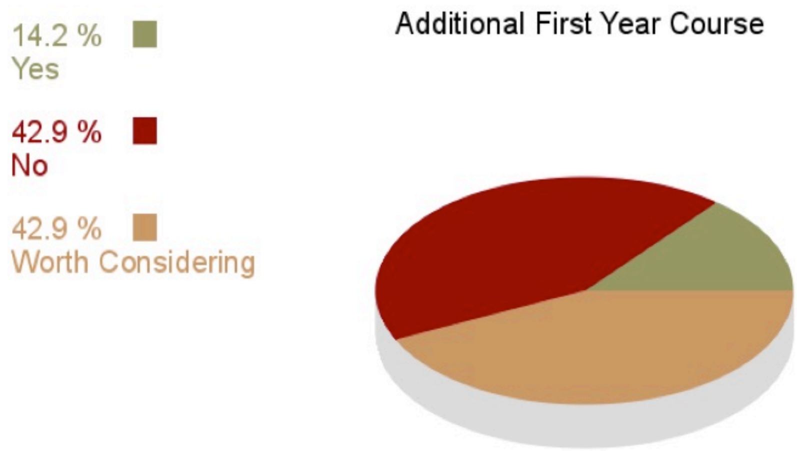

Figure 4 Professors' answers to whether they are for or against an additional first year course which would center on developing an increased awareness of environmental and sustainability issues.

The answers given by the professors for question 3 were evenly spread between no, and worth considering, with a small percentage answering yes, they are for an additional first year course which would center on developing an increased awareness of environmental and sustainability issues. These answers can be seen represented in Figure 4.

Questionnaire Questions Answered Using Average Rating, Standard Deviation, and IQR

Question 1 - In my courses I provide opportunities for students to explore the principles of sustainability

Question 1a:

The mean rating for question 1a was 2.666. On average the professors use and define terms such as sustainability, appropriate technology, intergenerational equity, renewable and non-renewable resources on a rare to occasional basis in their courses. The standard deviation for 1a is 1.505, with an IQR of 2

Question 1b

The mean rating for question 1b was 2.666. On average the professors emphasize that the effects of many activities extend in time beyond the current generation of humans on a rare to occasional basis in their courses. The standard deviation for 1b is 1.505, with an IQR of 2

Question 1c

The mean rating for question 1c was 2.833. On average the professors advance the precautionary principle as a basis for decision-making on a rare to occasional basis in their courses. The standard deviation for 1c was 1.834, with an IQR of 3.

Question 1d

The mean rating for questin 1d was 2.5. On average the professors promote the concept of qualitative as well as quantitative indicators of development on a rare to occasional basis in their courses. The standard deviation for 1d was 1.643, with an IQR of 3.5.

Question 2 - In my courses I provide opportunities for students to explore and justify their own environmental beliefs

Question 2a

The mean rating for question 2a was 2.333. On average the professors include role-plays or other exercises which highlight the different ways people value the environment, and the different attitudes they may hold on a rare to occasional basis in their courses. The standard deviation for 2a was 1.505, with an IQR of 2.5.

Question 2b

The mean rating for question 2b was 2.333. On average the professors debate or discuss specific areas of environmental concern on a rare to occasional basis in their courses. The standard deviation for 2b was 1.966, with an IQR of 4.

Question 3 - In my courses I explore global and local interconnections between the environment and other systems

Question 3a

The mean rating for question 3a was 2.333. On average the professors examine global effects of human activities on a rare to occasional basis in their courses. The standard deviation for 3a was 1.366, with an IQR of 1.5.

Question 3b

The mean rating for question 3b was 1. On average the professors teach that the prime goals of civilization are equity, justice, cultural development and environmental sustainability on a very rare basis in their courses. The standard deviation for 3b was 1.095, with an IQR of 2.

Question 3c

The mean rating for question 3c was 0.5. On average the professors stress individual and community improvement as the central goal of development never to very-rarely in their courses. The standard deviation for 3c was 0.836, with an IQR of 1.5.

Question 3d

The mean rating for question 3d was 2.833. On average the professors examine local environmental issues on a rare to occasional basis in their courses. The standard deviation for 3d was 1.471, with an IQR of 2.5.

Question 4 - In my courses I provide opportunities for students to explore the environmental implications of their own behavior

Question 4a

The mean rating for question 4a was 1.833. On average the professors explore impacts of personal lifestyle such as choice/ use of energy, food, clothes, cleaning materials, household appliances, transport, holidays on a very rare to rare occasion within their courses. The standard deviation for 4a was 1.169, with an IQR of 2.

Question 4b

The mean rating for question 4b was 1.5. On average the professors examine resource use and waste generation/ disposal at home and at university on a very rare to rare basis in their courses. The standard deviation for 4b was 1.378, with an IQR of 3.

Question 5 - In my courses I encourage students to make personal decisions which take account of the environment

Question 5a

The mean rating for question 5a was 2.666. On average the professors incorporate values and ethics into assignments and classroom procedures on a rare to occasional basis in their courses. The standard deviation for 5a was 1.643, with an IQR of 2.

Question 5b

The mean rating for question 5b was 2.5. On average the professors foster environmental values and attitudes, and a commitment to sustainable practice on a rare to occasion basis in their courses. The standard deviation for 5b was 1.643, with an IQR of 3.

Question 5c

The mean rating for question 5c was 4.333. On average the professors encourage the development of relevant personal skills, such as the ability to think creatively, make critical choices, and participate in local decision-making on a frequent to very frequent basis in their courses. The standard deviation for 5c was 0.816, with an IQR of 1.

Question 6 - In my teaching I utilize active, experiential and community service learning

Question 6a

The mean rating for question 6a was 2.5. On average the professors utilize active, experiential and community service learning on a rare to occasional basis in their courses. The standard deviation for 6a was 1.378, with an IQR of 1.

Question 7 - In my teaching I connect theories discussed in class with conditions and situations in the real world

Question 7a

The mean rating for question 7a was 4.5. On average the professors connect theories discussed in class with conditions and situations in the real world on a frequent to very frequent basis in their courses. The standard deviation for 7a was 0.547, with an IQR of 1.

Question 8 - In my teaching I take a transdisciplinary approach, where the issue comes before the discipline

Question 8a

The mean rating for question 8a was 3.5. On average the professors take a transdisciplinary approach, where the issue comes before the discipline, on an occasional to frequent basis in their courses. The standard deviation for 8a was 1.378, with an IQR of 3.

Discussion

Summary of research

This project focused on examining the extent of sustainability education in the engineering faculty currently at Dalhousie University. We chose to focus on the engineering faculty over all other faculties offered at Dalhousie University for several reasons. The first reason for this is because we believe that universities have immense impact on the future growth of societies and economies. Contemporary issues of exponential growth and sustainability are concerns to addressed by all professions and people. The reason our focus is engineers and their education is because in part of our preliminary research we identify that they are future developers who have lasting effects on the natural and built environments. Secondly, upon reviewing the programs and courses offered in the engineering faculty, we deduced there was a lack of sustainability concepts, of which required further investigation.

To aid our research project, preliminary research examined the Sustainable Tracking, Assessment and Rating System (STARS) Association for the Advancement of Sustainability in Higher Education (AASHE) program report (Okpala, 2015). This report "is a transparent, self-reporting framework for colleges and universities to make their sustainability performance" (Okapla, 2015). We examined the document and found 36 courses offered across seven departments of the engineering faculty included sustainability concepts. Where in comparison, the Agriculture faculty offers 65 courses that incorporate sustainability concepts

Our underlying motive was to incorporate more sustainability concepts throughout the engineering faculty and six of the seven departments (excluded the school of biomedical engineering – due to unconcern with the subject matter regarding our research motives). To begin this process, we had to start from the beginning and focus our research on what values and concepts are currently incorporated in the curriculum in order to know which areas need to revise and add additional sustainability concepts. We chose the best way to discuss what is being taught, is to talk to the ones who teach, the professors. Our population in focus of engineering professors at Dalhousie University from 6 or the 7 departments consisted of 56 people.

We decided on a questionnaire survey to collect our data, of which was piloted to take an average of seven minutes to complete. The questionnaires were sent out to all 56 professors in an email, followed by several reminder emails, a stack of 30 hard copies were dropped off at the department offices and administered to professor mailboxes, and finally, we went door-to-door in hopes to being in more responses. After all attempts to increase the response rate, we received a total of nine questionnaires back. The nine responses became the sample of our population of 56, equaling 16.07% response rate. From this low response rate we were unable to make a representative analysis and conclusions, though we were able to pull some trends and examine ways in which this research goal could be addressed further.

Overview of significant findings

This section provides an overview of the findings we were able to make from the data we did receive. From calculating the mean response for each of the 18 rating scale questions we saw high variability of mean responses between questions. We calculated interquartile range (IQR) and standard deviations as well as the means for each question. We provide a formal break down of each survey question and a visual display in a chart. Next we address the three open-ended short answer questions. Many of these questions were no extensively discusses by the respondents, as several replied, “I don’t know” or left them blank. From the replies we did receive we coded them using an a posteriori context sensitive scheme (see Appendix 5).

The first coding involves all responses given for open-ended question number one, where the codes collect were “a, b, b, d, d, f, z, z, h, c, c, g, u, t.”

1. Do you believe that engineering students at Dalhousie acquire an appropriate understanding of sustainable development/design through a four year Engineering undergraduate program, through which they will be equipped to integrate sustainability concepts into their projects?

The duplicated codes indicate reoccurrence and trends across questionnaires. For questions 1, b, d, z and c were duplicated. These codes are don’t know (b), Yes (d), Sustainability (z) and No (c). The reoccurrences of yes, no and I don’t know indicate a wide range of variability and inconsistencies between responses. We conclude that these inconsistencies are areas, which should be addressed by revising, adding and implementing the values of sustainability concepts throughout the faculty of engineering, to develop likeminded attitudes and values toward the need for sustainable design and products.

Open-ended question number two collected the codes as follows, “a, b, e, e, e, z, j, j, k, k, l, l, m, m, n, n, o, o, p, p, y, w, x, a2, a3.”

2. If any, what sustainability concepts do you believe to be the most important, and should be discussed thoroughly?

The most occurring codes are pollution (e), energy use (j), industrial waste (k), green tech (l), climate change (m), recycling (n), renewable resources (o) and non-renewable resources (p). Energy use (e) was the most occurring concept and stated to be the most important sustainability concept by the respondents.

The third open-ended question received the codes, “a, c, r, b, a5, a4, a6, s, q, y, z, a1, a7, d.”

3. What is your opinion regarding the potential implementation of an additional required first year course for engineering students to develop an increased awareness of environmental and sustainability issues?

There were no repetitive codes collected for this question, though themes still emerge. The codes collected were, no reply, no, waste of time, don’t know, worth considering, time constraints, second year, maybe, no need, life-skills, sustainability, ethics, time worthy, yes. Of these codes 3/14 expressed negative attitude that there is no need. 4/14 expressed interest and concern of implementation, but believe it is worth considering. There is great variability regarding this question, though further exploration of feasibility of implementation could provide clarity.

Existing research Studies

The Sustainability in Engineering Education and Research at U.S. Universities research article in the Environmental Science and Technology Feature magazine discusses research similar to ours. The research project is described as:

Two-dozen papers described approaches to evaluating the environmental footprints of products and processes, green design methods and case studies, and education reform. The papers were organized using a framework of 12 principles of Green Engineering (1), which paralleled the 12 principles of green chemistry identified by Anastas and Warner. The papers reflected growth in engineering research and education addressing sustainability, driven by societal attention to environmental issues, and increased funding for research in sustainable engineering (Murphy, 2009, p. 5558).

Furthermore, “The primary focus of the benchmarking effort was the distribution and analysis of two questionnaires regarding sustainable engineering education” (Murphy, 2009, p. 5558). 1300 questionnaires were sent to the heads of all academic units within the U.S. that included at least one Accreditation Board for Engineering and Technology (ABET) program, and nearly 300 responses were received (a 21% response rate) (Murphy, 2009, p. 5558).

The second questionnaire was more detailed and sent to an additional 327, engineering faculty identified as sustainable engineering champions (as recommended from department and programs heads, 10-year publication records from technical journals that focus on issues of sustainability, and by the Centre for Sustainability Engineering) (Murphy, 2009, p. 5558). Of the 327 sent, a total of 137 responses were collected, achieving a response rate of 43%.

The overall representation of engineering programs is <30% in the results reported here, the representation of highly rates engineering programs is more extensive. Murphy (2009) research contains:

Three fourths (73%) of engineering schools with Ph.D. programs and that ranked in the top 100 had at least one department that participated in the questionnaire (ranking numbers are in ref 3). Since more than 80% of the respondents reported some level of sustainable engineering course activity and 70% reported some sustainable engineering research activity, it is clear that teaching and research in sustainable engineering are part of the activities of most of the top 100 engineering programs in the U.S. As described in the full report, available at the CSE website (4, 5), the activity is most extensive at the largest institutions

The research examines extent of sustainability in two major categories: (1) courses, course modules, and curricula, and (2) research. In a table of sponsored research themes, ranked by number of projects, “As shown in Table 3, topical areas for research are heavily concentrated in energy and power systems”(Murphy, 2009, p. 5563). This correlates with our response to open-ended question number 2, where Energy use (e) was the most occurring concept and stated to be the most important sustainability concept by the respondents.

The research paper concludes by stating:

The path forward will require the development of a set of community standards for sustainable engineering. The benchmarking described here is an inventory of what is currently available and can serve as a resource as standards develop (Murphy, 2009, p. 5563).

Implications for theory and or/practice

Due to the low response rate our analysis and conclusions are unrepresentative. With a population size of 56, to have a margin of error of 2%, a confidence level of 95%, the require sample size would need to be 55. Due to the difficulties we have already experiences in making contact with professors it may not be possible to collect surveys from 55/56. Where we received a sample size of 9 we cannot make significant conclusions, though our research examines trends and sets the tone for continued research. We have discussed ways in which we could modify our research approach and things we could have done differently that may have produced greater response rates.

The first consideration is to change to a different target population, and develop a similar research question around Engineering student views and opinions around sustainable education.

For instance we could have tackled students who are more easily accessible, and asked upper level students how much sustainable education was emphasized in their earlier engineering classes. We could have asked similar open-ended questions to the students as well.

Secondly, we have discussed ways in which we could have approached our research through different means of collecting data. The first idea is to have initially gone door-to-door to create personal relationships with the professors early in our research, to have up to three weeks to ensure all professors had the time to provide their answers.

Thirdly, we could apply for DSUSO funding, to have an incentive to give to the professors or students (which ever population is deemed most suitable) upon completing our survey.

An incentive could be to have the respondents enter into a draw to win a $100.00 gift card to Pete'sToGoGo or arrange an agreement with Pete's to offer engineering professors a discount on coffee for a month upon completing our survey.

Finally, we could have done a deeper analysis simply comparing which courses contains sustainability concepts in the engineering faculty in comparison to other faculties. For example, by ranking each faculty regarding the extent of sustainability concepts in agriculture, science, humanities, commerce, management, architecture and planning, agriculture and so on, and do a comparison in lure of developing engineering and provide evidence for the need or adjustment.

The existing research article The Sustainability in Engineering Education and Research at U.S. Universities expresses issues regarding low recruitment and respondent rates similar to the difficulties we have met.

Conclusion

As mentioned above, our group had issues gaining participants for our study. We recognize that our data is not representative of the population, but do feel that this is a valuable project to pursue. Sustainable Education in Universities in invaluable, as these are the members of society to next enter the workforce. We cannot come to any reasonable conclusions that there is sufficient or insufficient sustainable education being taught in the faculty of engineering. We can conclude that more studies should be done to determine the extent to which sustainable education is being taught in this faculty, as well as other faculties at Dalhousie University.

We recommend that a full evaluation be carried out throughout the Engineering Faculty. As we did not have enough participants in our study, our answers are skewed and not representative of the population. It would also further benefit Dalhousie to complete this study with other faculties, to ensure that sustainable education is being taught throughout the school.

We would like to thank our teaching assistant Meggie MacMichael and our professor Tarah Wright for all their help along the way. We would also like to thank all the professors who took the time to help us with our research.

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Appendix

Appendix 1: List of engineering courses offered at Dalhousie (2013/2014) which have some sustainability related content.

List provided by Rochelle Owen, Director of the Office of Sustainability at Dalhousie (Owen, 2013).

·ENGN 3021.03: Ecohydrology UG Engineering Agriculture.

·PEAS 2202.03: Fundamentals of Environmental Engineering UG Process Engineering and applied science.

·CPST 3030.03: Engineering in Society II UG Complementary studies.

·CIVL 4460.03: Solid Waste & Landfill Engineering UG Civil and resource engineering.

·CIVL 4440.03: Water and Wastewater Treatment UG Civil and resource engineering.

·MINE 4815.03: Mining and the Environment UG Civil and resource engineering.

·MECH 4340.03: Energy Management I UG Mechanical engineering.

·MECH 4820.03: Energy from Renewable Resources UG Mechanical engineering.

·ENVE 4772.03: Environmental Assessment and Management UG Process engineering and applied science.

·ENVE 3251.03: Environmental and Industrial Microbiology UG Process engineering and applied science.

·ENVE 3412.03: Energy and Environment UG Process engineering and applied science.

·ENVE 4432.03: Waste Management UG Process engineering and applied science.

·ENVE 4421.03: Biogeochemistry and Bioremediation UG Process engineering and applied science.

·ENVE 4612.03: Waste Disposal and Utilization UG Process engineering and applied science.

·ENVE 4651.03: Solar Energy Utilization UG Process engineering and applied science.

·ENVE 4401.03: Design Project for Environmental Engineers I UG Process engineering and applied science.

·ENVE 4402.03: Design Project for Environmental Engineers II UG Process engineering and applied science.

·CIVL 3451.03: Water Quality and Treatment UG Civil and resource engineering.

·CIVL 4200.03: Transportation Systems UG Civil and resource engineering.

·CIVL 4410.03: Engineering Hydrogeology UG Civil and resource engineering.

·CIVL 4431.03: Water Distribution and Sewerage Systems UG Civil and resource engineering.

·ENGM 4675.03: Risk Assessment and Management UG Engineering mathematics and internetworking.

·ENGM 4680.03: Ecosystem Modelling of Marine and Freshwater Environments UG Engineering mathematics and internetworking.

·IENG 3301.03: Fundamentals of Industrial Engineering UG Industrial engineering.

·IENG 4558.03: Project Management and Control UG Industrial engineering.

·MECH 4810.03: Energy Conversion Systems UG Mechanical engineering Engineering.

·MECH 4851.03: Heating, Ventilating and Air Conditioning UG Mechanical engineering Engineering Ugursal, V.

·BIOE 4342.03: Industrial Biotechnology UG Process engineering and applied science.

·CHEE 4773.03: Industrial Safety and Loss Management UG Process engineering and applied science.

·ENVE 3452.03: Soil and Water Conservation Engineering UG Process engineering and applied science.

·ENVE 3500.03: Air Quality UG Process engineering and applied science.

·ENVE 4411.03: Indoor Environment Control and Air Quality UG Process engineering and applied science.

·ENVE 4621.03: Atmospheric Air Quality UG Process engineering and applied science.

·ENVE 4641.03: Contaminant Fate and Transport UG Process engineering and applied science.

·FOSC 3080.03: Food Microbiology UG Process engineering and applied science.

·MATL 4813.03: Iron and Steel Production UG Process engineering and applied science.

Appendix 2: E-mail template used for prospective interviewees.

Hello ______,

We are writing to you from the Environment Science: Campus as a Living Lab class. We are completing a project to determine to what extent sustainable education is being taught in Faculty of Engineering at Dalhousie.

We are hoping to get you to fill out a brief survey on this matter. We would be happy to come to your scheduled office hours to discuss this project with you, or can come by to drop off the survey. Can you suggest three times that work for you?

Looking forward to hearing from you,

Kate Pepler

Jennika Hunsinger

Ruthy Shvalbe

Kareem Wallace

Sean Cossey

Appendix 3: Questions that will be asked during the interview process.

Evaluating courses for sustainability. Adapted from BTEC 1993 and http://www.2nature.org/programs/starfish/courses/nsf

In my courses I …		0=Never 1=Very rarely 2=Rarely 3=Occasionally 4=Frequently 5=Very frequently
1	**Provide opportunities for students to explore the principles of sustainability**	
	a. use and define terms such as sustainability, appropriate technology, intergenerational equity, renewable and non-renewable resources	0 1 2 3 4 5
	b. emphasize that the effects of many activities extend in time beyond the current generation of humans	0 1 2 3 4 5
	c. advance the precautionary principle as a basis for decision-making	0 1 2 3 4 5
	d. promote the concept of qualitative as well as quantitative indicators of development	0 1 2 3 4 5
2	**Provide opportunities for students to explore and justify their own environmental beliefs**	
	a. include role plays or other exercises which highlight the different ways people value the environment, and the different attitudes they may hold	0 1 2 3 4 5
	b. debate or discuss specific areas of environmental concern	0 1 2 3 4 5
3	**Explore global and local interconnections between the environment and other systems**	
	a. examine global effects of human activities	0 1 2 3 4 5

	b. teach that the prime goals of civilization are equity, justice, cultural development and environmental sustainability	0 1 2 3 4 5
	c. stress individual and community improvement as the central goal of development	0 1 2 3 4 5
	d. examine local environmental issues	0 1 2 3 4 5
4	**Provide opportunities for students to explore the environmental implications of their own behavior**	
	a. explore impacts of personal lifestyle such as choice/ use of energy, food, clothes, cleaning materials, household appliances, transport, holidays	0 1 2 3 4 5
	b. examine resource use and waste generation/ disposal at home and at university	0 1 2 3 4 5
5	**Encourage students to make personal decisions which take account of the environment**	
	a. incorporate values and ethics into assignments and classroom procedures	0 1 2 3 4 5
	b. foster environmental values and attitudes, and a commitment to sustainable practice	0 1 2 3 4 5
	c. encourage the development of relevant personal skills, such as the ability to think creatively, make critical choices, and participate in local decision-making.	0 1 2 3 4 5
In my teaching I …		0=Never 1=Very rarely 2=Rarely 3=Occasionally 4=Frequently 5=Very frequently
6	Utilize active, experiential and community service learning	0 1 2 3 4 5

7	Connect theories discussed in class with conditions and situations in the real world	0 1 2 3 4 5
8	Take a transdisciplinary approach, where the issue comes before the discipline	0 1 2 3 4 5

Other Questions:

1. Do you believe that engineering students at Dalhousie acquire an appropriate understanding of sustainable development/design through a four year Engineering undergraduate program, through which they will be equipped to integrate sustainability concepts into their projects?
2. If any, what sustainability concepts do you believe to be the most important, and should be discussed thoroughly?
3. What is your opinion regarding the potential implementation of an additional required first year course for engineering students to develop an increased awareness of environmental and sustainability issues?

Appendix 4: Schedule

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
22	23	24	25	26 Proposal Due Midnight	27	28
1 MARCH	2	3 Lab 3 due @ 5pm Finalize Interview Questions	4 Meet: 9am-10am Look up & Contact Interviewees (professors)	5 Meet: 3-4pm Pilot interviews	6	7
8	9 Conduct Interview(s)	10 Conduct Interview(s) Test	11 Conduct Interview(s)	12 Conduct Interview(s)	13 Conduct Interview(s)	14
15	16 Meet: 6pm Compile & Analyze Data	17	18 Meet: 9-10am Continue Analysis	19 Meet: 3-4pm Progress Report	20	21
22	23 Meet: 6pm Pecha Kucha Preparation	24 Lab 4 due @ 5pm Group Meeting (In lecture)	25	26 Meet: 3-4pm Progress Report/finalize Pecha Kucha	27	28
29 Presentation slides @ midnight	30	31 Pecha Kucha presentations	1 APRIL	2 Meet: 3-4pm Compile Final Report	3	4
5 Presentation slides @ midnight	6	7 Pecha Kucha presentations	8	9 Meet: 3-4pm Continue Final Report	10	11
12	13	14	15 Meet: 9-10am Group Meeting to Finalize Report	16	17 Due: Final Report & peer assessment by midnight	18

Appendix 5: Appendix 2: Coding for Opinion Questions

Table 2 Opinion Codes

No reply	a	waste of time	r
Don't know	b	maybe	s
No	c	Promotion	t
Yes	d	Too-narrow	u
Pollution	e	Emphisize	v
Adequate	f	Harmony	w
Lacking	g	Nature	x
Varying	h	Life-skills	y
energy use	j	Sustatainability	Z
industrial waste	k	Ethics	a1
green tech	l	People	a2
climate change	m	Inter-gen justice	a3
recyling	n	Time contraints	a4
renewable resource	o	Worth considering	a5
non renewable resource	p	Second year	a6
no need	q	Time worthy	a7

1. Do you believe that engineering students at Dalhousie acquire an appropriate understanding of sustainable development/design through a four year Engineering undergraduate program, through which they will be equipped to integrate sustainability concepts into their projects?

Opinion 1 a, b, d, f, z, h, c, g, d, c, t, z, b, u

Reordered a, b, b, d, d, f, z, z, h, c, c, g, u, t

Prof 1: No answer

a

Prof 2: I don't know.

b

Prof 3: Yes, the students in Environmental Engineering will acquire an appropriate understanding of sustainability to carry it into their engineering practice.

d, f, z

Prof 4: It may vary a lot by discipline, and I only know the Industrial Engineering Curriculum. I do not think that we cover sustainability issues sufficiently.

h, c, g

Prof 7: Yes

d

Prof 8: No. I promote sustainability in all my courses but I am not sure if that is done in other classes which concentrate on providing information on the narrow width of the specific course.

c, t, z, b, u

2. If any, what sustainability concepts do you believe to be the most important, and should be discussed thoroughly?

Opinon 2 a, b, e, z, j, e, k, l, m, n, o, p, e, j, k, l, m, o, p, y, w, x, a2, a3

Reordered a, b, e, e, e, z, j, j, k, k, l, l, m, m, n, n, o, o, p, p, y, w, x, a2, a3

Prof 1: No answer

a

Prof 2: I don't know.

b

Prof 3: Speaking from my own experience, pollution control (and hence sustainability) is one major focus of the environmental engineering program and is thoroughly discussed.

e, z, (interesting that pollution control= sustainability to this prof)

Prof 4: From an engineering point of view, some of the key concepts are energy use, industrial pollution, industrial waste, green technologies, climate change, recycling, resource use (renewable and non-renewable).

j, e, k, l, m, n, o, p

Prof 7: all are important.

(all?) e, j, k, l, m, n, o, p

Prof 8: I strongly believe that an education should emphasize more on life skills. i.e. how to live harmoniously with nature and people around us instead of focusing on the selfish interest of present generation while damaging the nature for comfortable living of future generation.

y, w, x, a2, a3

3. What is your opinion regarding the potential implementation of an additional required first year course for engineering students to develop an increased awareness of environmental and sustainability issues?

Opinion 3 a, c, r, b, a5, a4, a6, s, q, y, z, a1, a7, d

Reordered a, c, r, b, a5, a4, a6, s, q, y, z, a1, a7, d

Prof 1: No answer

a

Prof 2: It seems to me that providing sustainable designs really just involves common sense and doesn't require a full course. There are LOTS of courses that would be more valuable to engineering students (e.g., the solution of partial differential equations, since PDE's are the backbone of engineering principles). Finding the time to include these other courses is the problem.

c, r,

Prof 3: I don’t know.

b

Prof 4: I think that it is worth considering, but of course what it displaces must be taken into account. Also, I think it would be better in second year than first year.

a5, a4, a6, s

Prof 7: not needed.

q

Prof 8: Many of the complementary studies could be replaced with one or more on life skill that will promote sustainability in terms of environment as well as ethical living.

y, z, a1, a7, d