Teaching Students about Social Entrepreneurship within the Context of Sustainability

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This paper describes the redesign and implementation of a course that introduces engineering students to social entrepreneurship within the context of sustainability, at the University of Pittsburgh. Throughout the semester, the course focuses on three overarching topics: the concept of wicked problems, the concept of sustainability and climate change (as an example of a wicked problem), and social entrepreneurship. The author took responsibility of this course in 2015, and this paper focuses on the redesign of this course since that time.

This course is an elective that is mostly taken by junior and senior engineering students of all engineering disciplines at the university. Throughout the semester, students are introduced to entrepreneurship topics, the entrepreneurial process, and the business model canvas, and work in teams of three to four students on what will be their final deliverable at the end of the semester: a business plan for a social enterprise of their creation, that addresses a sustainability/climate issue.

The course has been very successful in its implementation, with consistently positive comments from students. This paper provides an overview of the course, course topics, and course assignments. The course places a strong emphasis on the positive impact businesses and entrepreneurial pursuits can have on addressing societal problems, and in particular on addressing climate change, and highlights the positive role engineers can have on humanity. These foci have been found to be especially attractive to underrepresented groups in engineering.

The purpose of this paper is to describe the course and assess its effectiveness both in terms of implementation and in terms of student learning. Specifically, this paper will: (1) describe the course objectives, course topics, and course assignments, (2) describe what has worked well and identify areas for improvement, (3) provide recommendations for other faculty interested in implementing a similar course or incorporating these themes into already-existing courses, and (4) summarize students' perceptions of and learning within the course. To evaluate student learning and feedback on the course, a final reflection assignment, as well as comments within teaching evaluation surveys, both completed by students at the end of the semester, were qualitatively analyzed, and the common themes are included in this paper.

Because detailed information about the course and course assignments, as well as suggestions for improvement, will be provided, this paper will be especially relevant to faculty who are (1) interested in incorporating activities to teach about entrepreneurship, (2) interested in teaching about sustainability, and/or (3) interested in teaching about the positive impact that entrepreneurial pursuits can have to address humanitarian issues.

Introduction

ENGR 1060 (Social Entrepreneurship: Engineering for Humanity) is a course offered as an elective to engineering students at the University of Pittsburgh. The author took over this course in 2015 and has redesigned the course to include a variety of sustainability and climate change (S/CC) topics situated within the context of social entrepreneurship and wicked problems (WPs). Since 2015, the author has been periodically modifying and improving the course. This paper

describes the redesign and implementation of this course since 2015, focusing on the section taught in 2023, as the most recent iteration of the course.

The course focuses on three overarching topics:

1. **Wicked problems (WPs)**. WPs are defined as very complex problems. They are hard to define and are characterized by having no stopping point, no point in which the problem has been clearly "solved" [1]. Climate change has been described as an example of a WP [2].
2. **Sustainability and climate change (S/CC) topics.** S/CC problems have recently been coming to the forefront as problems that need to be urgently addressed. Given the important role engineers play in transportation, manufacturing, design, and other areas relevant to S/CC, it is important for engineering students to be exposed to these topics throughout their studies.
    - Within S/CC topics, the concept of circularity (as in the circular economy) is discussed and included as a requirement for student projects. In this course and in this paper, circularity is referred to as Cradle to Cradle (C2C), based on the book by McDonough and Braungart [3]. The C2C approach promotes a change from a cradle-to-grave design of a product (a product is created, used, then disposed of), to a cradle-to-cradle approach, in which the materials used to create the product continue to be reused after that particular product has concluded its use.
3. **Social entrepreneurship**. In this course, social entrepreneurship is defined as using business and entrepreneurship to create some kind of social and/or environmental good, while focusing on the 3Ps: people, profit, and planet. It is a way to positively address a societal or environmental concern through the use of a business endeavor. Multiple social enterprises currently exist to address S/CC problems, many of which are discussed throughout the course of the semester.

The purpose of this paper is to describe the course and assess its effectiveness both in terms of implementation and in terms of student learning. Specifically, this paper will: (1) describe the course objectives, course topics, and course assignments, (2) describe what has worked well and identify areas for improvement, (3) provide recommendations for other faculty interested in implementing a similar course or incorporating these themes into already-existing courses, and (4) summarize students' perceptions of and learning within the course.

Course Description

This section of the paper will focus on addressing the first purpose of this paper: to describe the course objectives, course topics, and course assignments.

Course Overview

ENGR 1060 is an elective that is offered once per academic year, has been taught by the same instructor (the author) since 2015, and is mostly taken by junior and senior engineering students of all engineering disciplines at the university. Enrollment is currently capped at 30

undergraduate students per semester. It is a three-credit course that meets twice a week, with each class session being one hour and fifteen minutes long.

Throughout the semester, students are introduced to entrepreneurship topics, the entrepreneurial process, and the business model canvas, and work in teams of three to four students on what will be their final deliverable at the end of the semester: a business plan for a social enterprise of their creation, that addresses a S/CC issue while incorporating C2C principles.

The course description provided in the syllabus is:

> *This course will explore the concept of social entrepreneurship through the lens of sustainability and the context of complex or "wicked" problems. An introduction will provide a foundation in sustainability and social entrepreneurship while exploring methods for analyzing wicked problems. The course project will provide students with an opportunity to work with a team to design a business plan targeting a specific challenge. The course will focus on core concepts and interdisciplinary approaches to create a foundation for students to become agents of change.*

The course objectives, as listed in the syllabus, are:

- *Define social entrepreneurship, sustainability, and wicked problems.*
- *Analyze a wicked problem in terms of its many causes and components (technical, political, social, etc.).*
- *Apply principles of social entrepreneurship to create an implementable business plan for a social enterprise.*
- *Contribute on team-based projects.*
- *Examine the ethical and professional responsibilities of engineers in a global, social, and environmental context.*

The course consists of four main types of assignments:

- **Team project and corresponding deliverables** (30% of the final grade): The team project is to ideate a social enterprise that addresses a S/CC-focused problem while incorporating C2C principles. Throughout the semester, students complete different team deliverables (further described below) that will take them step by step through the process, culminating in the final deliverable, which is a business plan for this social enterprise.
- **Individual learning assignments, or ILAs** (30% of the grade): For these ILAs, a general prompt is given, and students then write a 600-1000 word essay answering the prompt.
- **Reading questions** (20% of the grade): These are reflection questions students answer after they read/view the resources (videos/articles) assigned prior to a given class period.
- **Attendance and class discussions** (20% of the grade): The class relies heavily on in-class discussions, so attendance is taken and there is a point deduction after more than two unexcused absences. Class discussions typically end with students individually submitting a response to a question that is based on the in-class discussion they just had.

This is the information provided to students in the syllabus regarding the course assignments:

> *You will be graded as indicated below. This class will mainly consist of the following:*
> - ***In-class discussions about social entrepreneurship, wicked problems, and sustainability.*** *In preparation for these discussions, I will provide you with materials (articles and/or videos) for you to review prior to class. As part of this preparation, you will be asked to answer short reflection questions about the materials you reviewed. Because attendance and in-class participation are important components of this class, every two unexcused absences will result in a deduction of one letter grade on your final course grade.*
> - ***Team project consisting of multiple deliverables throughout the semester.*** *Your team will be creating a social enterprise to address a wicked problem.*
> - ***Individual learning assignments.*** *These will allow you to learn more about certain topics. I will provide a general prompt, but you then get to narrow down to a topic of interest.*

Course Topics

The course begins by providing a general introduction to the main course topics: WPs, S/CC, and social entrepreneurship. Then, most weeks, the week is split up such that (a) one class period focuses on a different S/CC-focused WP each time, as well as how this problem can be addressed via policy changes, individual changes, and social enterprises, and (b) the other class period focuses on aspects of entrepreneurship, typically one or more elements of the business model canvas.

Regarding (a), students are provided with materials (videos and/or articles) compiled by the author that provide an introduction to the S/CC topic of the week (topics are listed below). After reviewing those materials, students answer some reflection questions (RQs) about what they learned. This is intended to be done prior to the class period in which the topic will be discussed, so that they come to class already having some baseline knowledge about the topic. During class, there is a short lecture providing more in-depth information about the problem and how this problem can be addressed, and this is followed by discussion among student pairs/teams, whole-class discussion, and/or an in-class activity.

Regarding (b), these class periods typically begin with a short lecture on the entrepreneurship or business model canvas topic for that day, and is sometimes followed with time for students to work with their teams addressing that particular topic in the context of their team project. For example, when the topic of "value proposition" is discussed in class, this might be followed with some class time in which student teams discuss what the value proposition might be for the social enterprise they are ideating as part of their project.

A list of all topics covered in the course is provided in Table 1 below, categorized according to the three overarching course topics of WPs, social entrepreneurship, and S/CC. Regarding the S/CC topics, students receive a general introduction to the topics of sustainability and climate change, and then throughout the semester, learn about additional, different S/CC-focused problems. In addition to learning about each problem, emphasis is placed on how each problem

can be addressed through three different paths: through policy changes, through individual changes, and through social entrepreneurship. Examples of businesses and social enterprises addressing each problem are shared with students. In addition, because their project requires that they incorporate C2C in some way, this concept is included in discussions on sustainability.

Table 1: Course topics addressed throughout the semester

Overarching topic:	Topics taught:
Wicked problems	• Definition of WPs • Characteristics of WPs • Correct and incorrect ways to approach a WP • Different strategies for addressing a WP • Systems thinking • Different types of WPs
Sustainability and climate change	• Introduction to the climate crisis • The concept of C2C, C2C certifications, C2C examples, C2C Case study (Puma InCycle) • Introduction to biomimicry • The role of policy-based and individual-based approaches in addressing S/CC • Food waste • Processed vs. unprocessed foods • Toxins in water and personal care products • Animal agriculture and factory farming • Transportation • Climate initiatives and perspectives from different countries • Waste (trash) • Fast fashion • Consumerism • The role of ethics/integrity in the climate crisis • Sustainability and design (how the way we design can enable sustainability)
Social entrepreneurship	• Introduction to social entrepreneurship • Introduction to customer discovery and interviewing tips • Case studies: TOMS, Grameen Bank, TerraCycle, PlayPump and Farm Truck Foods (the last two as business ideas that ended up not working) • The business model canvas and its components: Value proposition and ways to create value in general and as a social enterprise in particular, customer segments, customer relationships, channels, key resources, key activities, key partnerships, cost structures, revenue streams • Benchmarking and analyzing the competition • Introduction to business models, plus examples of business models in general and used in social enterprises in particular • Stakeholders • For profit and not for profit structures, benefit corporations, and B Corporations (B Corps) • Measuring impact as a social enterprise • Business plans

Course Assignments

This section provides more information about some of the in-class activities, the ILAs, and team assignments completed by students.

In-class activities

In addition to a lecture, class time always involves interaction of some sort, typically through the use of discussions with a partner, within a team, or as a whole class. Some class periods have additional or different ways to incorporate interaction and hands-on learning. Below is a selection of activities that the instructor has experienced as being effective at teaching the concepts they intended to address:

- **Water footprint activity.** In this activity, students complete an online questionnaire [4] about daily life choices. This online tool provides information about the environmental impact of the different decisions, introducing students to which actions are more and less impactful.
- **Activity to identify a problem**. In this activity, a picture of a messy closet is provided to students, and they are tasked to identify the problem, without yet thinking about the possible solutions. This activity was incorporated after the author noticed how, when identifying the problem they want to address (for example, food waste or fast fashion), students immediately started thinking of solutions instead of further trying to understand the problem and how people experienced the problem. This activity is done prior to students conducting their first round of customer discovery for their project, to emphasize the importance of learning as much as possible about the problem instead of jumping straight to solutions.
- **Informal peer feedback**. In this activity, each team is split into two and matched with a pair from a different team. They give each other feedback on their initial ideas for their social enterprises. Then, each team reconvenes and shares the feedback they received. This activity can be repeated multiple times throughout the semester, if desired.
- **Transportation jigsaw**. In this activity, students are tasked with helping the local mayor identify what to prioritize in a project aiming at redesigning the city such that emissions from transportation are lowered: should a priority be to redesign the city to maximize walking/biking, use of public transportation, use of car sharing, or use of electric vehicles? Student project teams are split up such that each team member goes to a new "expert" team. These expert teams focus on learning as much as they can about their assigned mode of transportation (walking/biking, public transportation, car sharing, and electric vehicles) and their environmental impact. Then, students return to their original teams and discuss what they learned. The knowledge they share with each other is used to determine a recommendation for the mayor. Through this activity, students learn about the environmental impact of the indicated modes of transportation, and learn to consider the needs of the different stakeholders involved.
- **"Making Toast" activity, as described by Tom Wujec [5], to learn about systems thinking**. In this activity, students individually sketch out the steps to make toast, and then compare their work to other students' work. The steps often differ, illustrating how

different individuals might perceive the same problem differently. Students then repeat the process as a team. As a team, their steps are often more numerous and more detailed. When they compare their work to other teams' work, they see that even then there are differences in how the problem is portrayed. It is a great activity to illustrate points such as how our biases affect our perceptions of the problem, how different components or parts of the problem are interrelated with each other, and how a team is better able to identify the components of the problem as compared to an individual. After doing this activity with "making toast" as the prompt, student teams then repeat the exercise with the problem they plan to address for their project. More information about the "making toast" activity can be found in Tom Wujec's TED Talk [5].

- **Modified "60 minute MVP" activity [6], as described by Teaching Entrepreneurship**. In this activity, student teams have 60 minutes in class to create a landing page for a website for the social enterprise they are creating as part of their project. Within their website, they should include a video describing how their social enterprise will add value to their customer segments. This activity teaches about MVPs (minimum viable products) and communicating value. More information about this activity can be found in the Teaching Entrepreneurship website [6].

Team project deliverables

The team project is to create a social enterprise that addresses a S/CC problem while also incorporating C2C principles. The different team project deliverables that were submitted throughout the semester are:

- **Team1 (Background and observations)**: After student teams have selected the problem they would like to address via a social enterprise (for example, food waste, fast fashion, etc.), they conduct some research to learn more about the problem and its environmental impact. Then, they conduct passive (silent) observations to see how individuals engage with the problem. For this assignment, they simply observe at a public location and do not interact with the individuals they observe.
- **Team2 (Customer discovery 1)**: Student teams interview users/customers to learn more about how they experience and engage with the problem.
- **Team3.1 (Business plan 1 presentation)**: Student teams present about their selected problem, the product or service they intend to offer via their social enterprise, their value proposition, and how they plan to incorporate C2C. As they present, the rest of the class completes a feedback survey, and these responses are shared with each team as additional feedback on their ideas. Student teams were encouraged to incorporate this feedback into their first business plan draft (Team3.2).
- **Team3.2 (Business plan draft 1)**: Student teams start to write in elements of their business plan. For this first draft, they write a short background on the problem and describe the product or service they intend to offer, their value proposition, and how their social enterprise will incorporate C2C.
- **Team4 (Planning the business)**: Now that student teams have received feedback on their product/service and value proposition, they begin to think about some of the business

components, specifically, how their social enterprise will generate money, what they expect some of the expenses will be and whether their intended revenue will be sufficient to cover these expenses, and an initial hypothesis as to who their customers might be.

- **Team5 (Customer discovery 2)**: Student teams again conduct interviews, this time especially seeking to refine their value proposition and customer segments.
- **Team6 (Business plan draft 2)**: For this second draft, student teams add on these elements to their business plan draft: a description of the current state of the industry they expect to enter; a description of their competition, their competitors' strengths and weaknesses, and how they differ from the competition; and customer segment, customer relationships, and channels. In addition, student teams are expected to incorporate the feedback provided by the instructor after reviewing their first draft.
- **Team7 (Business plan draft 3)**: For this third draft, student teams add on these elements to their business plan draft: resources, activities, and partners; and cost and revenue streams. In addition, student teams are expected to incorporate the feedback provided by the instructor after reviewing their second draft.
- **Team8.1 (MVP)**: This assignment is what student teams submit upon completing the "60 minute MVP" in-class activity described above (they submit a link to the webpage they created).
- **Team8.2 (Customer discovery 3)**: Student teams again conduct interviews, this time especially seeking feedback on their MVP.
- **Team9 (Final presentation)**: Student teams present on the problem they are addressing, how their social enterprise addresses the problem, how their social enterprise adds value to the customer, who their customer is, and how their social enterprise will make money. They are also expected to show their MVP.
- **Team10 (Business plan draft 4)**: For this fourth and final draft, student teams add on these elements to their business plan draft: metrics and impact; team information; and an Executive Summary at the beginning of the business plan document. In addition, student teams are expected to incorporate the feedback provided by the instructor after reviewing their third draft.
- **Peer evaluations**: Students complete three peer evaluations throughout the semester, using the CATME software [7].

Individual learning assignments (ILAs)

The different ILAs that were submitted throughout the semester are below. ILA1 and ILA2 are based on assignments since before the author took over this course; the remaining ILAs were developed by the author. With the exception of ILA5, which was expected to be a 300-500 word submission, all ILAs are expected to be 600-1000 words.

- **ILA1**: Students write about a WP of their choice, explain the characteristics of the problem that make it a WP, provide two examples of stakeholders for this problem, and indicate why the problem matters to them personally.
- **ILA2**: Students write about a social enterprise of their choice, identify the problem and need they target, explain how they make and spend money, describe what makes them

different from a traditional business and what makes them different from a traditional charity, and include some kind of metric as evidence regarding whether or not they have made an impact on their targeted problem.

- **ILA3**: Students write about a sustainability-focused policy or initiative applied in a country other than the United States, describe its effects by including some kind of metric, compare to what is (or is not) being done about that same problem in the U.S., and provide their opinion about those approach(es) to address the problem.
- **ILA4**: Students pick a product/service of their choice and write about its hidden (social and environmental) costs, describe some of the elements that could/should be included in the price tag, and describe what the status quo means for social enterprises that want to target that market.
- **ILA5**: Students write a final, short reflection about what they learned that semester (more information about ILA5 is provided in the next section).

Full assignment descriptions, as well as the list of resources and videos provided to students, can be provided by the author upon request. A copy of the semester schedule, indicating when the different topics, activities, and assignments were incorporated that semester, is included in Appendix A, to provide readers with further clarity and understanding regarding the course.

The course has been very successful in its implementation, with consistently positive comments from students. It places a strong emphasis on the positive impact businesses and entrepreneurial pursuits can have on addressing societal problems, and in particular on addressing S/CC issues, and highlights the positive role engineers can have on humanity. Focusing on the societal impact that engineers can have can be especially attractive to underrepresented groups in engineering [8].

Data Analysis and Results

This section of the paper provides information on the data analyzed to determine information to address the second, third, and fourth purposes of this paper: (2) describe what has worked well and identify areas for improvement, (3) provide recommendations for other faculty interested in implementing a similar course or incorporating these themes into already-existing courses, and (4) summarize students' perceptions of and learning within the course.

To evaluate student learning and feedback on the course, ILA5, as well as comments within teaching evaluation surveys, both completed by students at the end of the semester, were qualitatively analyzed. This data corresponds to the iteration of the course taught in 2023, which is the most current version of the course and modifications. While data from 2022 and 2021 are available, the sections taught these years are not fully comparable to the section taught in 2023. Specifically, the 2022 section had differences in some of the assignments and in-class activities used, and the 2021 version was taught remotely, due to the COVID-19 pandemic, which resulted in some necessary modifications due to the course being remote. The data from the 2023 section of the class represents feedback that aligns with the most recent version of assignments and in-class activities used.

ILA5 is a reflection assigned the last week of the semester. The instructions provided to students are:

> Please write a short (300-500 words) response reflecting on what you have learned this semester. You can use one of the prompts below:
>
> Regarding __#below___, I have learned _____ .
>
> OR
>
> Regarding __#below___, I used to think _____, and now I have learned _____ .
>
> #s:
>
> 1. social entrepreneurship
> 2. sustainability and environmental issues (in general or specific ones – food, waste, etc.)
> 3. what I can do to address societal/environmental issues
>
> You are not required to write about all three topics (1, 2, 3 above). You should write about at least one of the topics, and are welcome to write about more than that if you like.

To analyze this data, open coding was used: student submissions and responses were read and categories and subcategories emerged from the data itself [9], then responses were grouped according to these categories.

All 27 students enrolled in the course in the spring 2023 semester completed the ILA5 assignment. The required word count was 300-500 words. Submissions had an average word count of 423, with a minimum of 298 and maximum of 742 words.

The codes that emerged aligned well with the assignment instructions: students tended to discuss what they learned about social entrepreneurship, S/CC issues, and what they can do to address S/CC issues. The codes were classified under the following themes: their perceptions and knowledge at the start of the semester (before participating in the course), what they learned from the course, the impact the course has had on them personally or professionally, discussion of class activities, positive comments about the class and/or instructor, and the need to teach these topics more broadly. The table below provides more detailed information of the codes that emerged, including the percentage of students (in total and by gender) that indicated each one. Note that the codes below are those that were mentioned by at least two students; codes mentioned by only one student were not included.

Table 2: Summary of codes that emerged from the ILA5 student submissions

	Codes	Percent of female students (n=17)	Percent of male students (n=10)	Percent of entire class (n=27)
At the start of the semester:	Had some awareness of S/CC issues, though superficial or with misconceptions	29.4	10.0	22.2
	Had some awareness of social enterprises/entrepreneurship, though typically with some misconception	11.8	20.0	14.8
	Thought individual actions didn't matter	5.9	30.0	14.8
	Did not know about social enterprises/entrepreneurship	11.8	0.0	7.4
Topics learned:	About S/CC in general or specific topic, plus potential solutions	94.1	70.0	**85.2**
	About social enterprises, social entrepreneurship, and entrepreneurship	52.9	70.0	**59.3**
	About the impact of individual actions	52.9	50.0	**51.9**
	About the impact/role of governments	11.8	0.0	7.4
	That current or past actions were already sustainable	11.8	0.0	7.4
Impact of the course:	Students currently taking action (have made changes regarding S/CC) or planning/desiring to	58.8	50.0	**55.6**
	Students indicating professional impact	23.5	20.0	22.2
	Students currently sharing or planning to share S/CC knowledge with others	17.6	0.0	11.1
Impactful/mentioned class activities	Water footprint activity	5.9	10.0	7.4
	Case studies	17.6	20.0	18.5
	Project	5.9	10.0	7.4
	ILA assignments	11.8	0.0	7.4
Positive comments:	About class or instructor	11.8	20.0	14.8
Teaching these topics more broadly:	These topics need to be taught to others (children, other engineering students, be included as degree requirements)	11.8	20.0	14.8

** indicate codes mentioned by at least 50% of students; highlights indicate gender differences.

Regarding what students thought at the start of the semester, students mentioned that they had some initial awareness of the course topics, but often with some misconceptions or incomplete knowledge. For example:

> *"I thought I had a pretty good understanding of environmental issues like CO2 emissions and global warming, but what I did not know before this class is how interconnected sustainability issues truly are. (I also came to realize that I definitely did not know as much as I thought I did)."*

> *"I had never heard of social entrepreneurship before and thought the only kind of enterprises that centered around helping people were non-profits. I knew that some*

businesses donated a small portion of their proceeds to charities but [had] a cynical view that these good acts were at least partially for tax write offs. I had never really thought about how a for profit business could be centered around helping people or the environment because I had constantly just heard about corporate greed."

Regarding topics learned, students mostly mentioned learning about S/CC topics, whether in general or specific S/CC topics, and often including potential solutions. For example:

"…I found reading about the food waste problem particularly enlightening. I knew nothing about the large extent of this issue before this class, and I was definitely shocked to see the statistics of how wasteful we are with food in America…"

"Sustainability and environmental issues have also been an essential focus of my learning this semester. In particular, I have become more aware of the interconnected nature of global food systems, waste management, and their impacts on the environment. I used to think that sustainability was primarily about recycling and reducing waste, but now I realize that it is a much more complex and systemic issue."

Students also mentioned learning about entrepreneurship and social entrepreneurship, and about the impact of individual actions. For example:

"This semester, I have gained a deeper understanding of the various facets of social entrepreneurship, from business models and organizational structures to ethical considerations and impact measurement."

"…regarding what I can do to address societal and environmental issues, I used to think that my actions as an individual had a limited impact on a global scale. However, throughout this semester, I have learned that every action counts and that I can actively create positive change."

Regarding the impact of the course, students discussed actions they have started to take, or plan to begin taking, as a result of what they've learned. For example:

"I started cutting meat out of my diet, making my own oat milk, and trying to reduce the amount of single-use plastics I interact with daily. I researched places to buy bulk goods I could put in my own containers and green city design. This class made me reexamine the way I choose to go through life and has caused me to make changes that I wouldn't have expected to make in my life even just a few months ago."

"This made me really rethink the way I used food. I was more careful about not buying too much food, especially fruits and vegetables that go bad quickly. I also made sure I was taking leftovers home when going to a restaurant."

Impact of the course was also seen in terms of how the course will affect their future professional work, and also how they have started sharing information about the course (specifically on S/CC topics) with others. For example:

"I still hope to build a career for myself in the cosmetics industry, but now I want to go in with the hopes of trying to make a difference in the ingredients and materials used in the products put out."

"My favorite unit in this class was about infrastructure and transportation in city design and I really want to keep learning more about it. Since taking this class, I have decided to get a minor in civil engineering and I'm considering getting a master's in civil engineering and urban planning. Overall, this class has changed my life and my future."

"I also plan to share what I have learned with other people to help them understand the harm brought about by animal agriculture."

Some students wrote about specific class activities, which is noteworthy because discussing class activities was not explicitly required in the instructions. The class activities that were mentioned by students included the water footprint activity, case studies of social enterprises, the semester-long project, and ILAs. For example:

"I found case [study] discussions on social enterprises very intriguing since we would tackle how they can fail and what sustains them, highlighting the idea of constantly re-learning and changing business models."

"I think the lesson that made me reevaluate my behavior was the one where we calculated the amount of water we use daily. Until that point, I considered myself a rather sustainable person so I was shocked when I saw just how much water I use living my life. I was even more shocked to learn that the value was low compared to the average person."

Regarding positive comments, some students included positive comments about the course and/or instructor. For example:

" I feel I have learned more about the world and all its problems within the span of 4 months than I have in my entire life. Thank you for helping me to be more informed. I don't think I'll ever forget this class and the ways it has changed my perspective."

"In general, [the instructor] reinforced these ideas by sharing [their] personal journey in sustainability […] This enthusiasm and endorsement inspired greater agency in me than I have in a while."

Finally, students mentioned a need to teach these topics to others, whether teaching them to children, teaching them to other engineering students, or including these topics as degree requirements. For example:

"In engineering classes, such issues aren't the focus of the material, and many students aren't aware of the process of developing sustainable products. In the future, I hope to find [the University's engineering program] implementing environmental classes in their degree requirements. Courses such as [this one] can be beneficial for engineering students."

> *"I think all engineers should take this class as I think a lot of engineers (including myself) get too focused on the technical side of things and don't take the time to care about world issues, including those in sustainability."*

The topics that were mentioned the most by students (mentioned by at least 50% of the students, and marked with asterisks in the last column of Table 2) were: (1) what they learned about S/CC topics (85.2% of the class), whether in general or specific topics, often including potential solutions; (2) what they learned about social enterprises, social entrepreneurship, and overall entrepreneurship (59.3% of the class); (3) how they are, as a result of what they learned, now taking and/or planning to take some kind of action to address S/CC issues (55.6% of the class); and (4) what they learned about the impact of individual actions on S/CC issues (51.9% of the class). Having these topics being the ones most mentioned by students makes sense, as this would closely align with the assignment instructions.

The table also highlights some items in which a gender difference was noticeable. These are items in which there is a difference of at least 15 percentage points between male and female students. Female students were more likely than male students to talk about S/CC topics (94.1% of female students, 70% of male students), while male students were more likely than female students to talk about entrepreneurship topics (70% of male students, 52.9% of female students). In addition, 17.6% of female students mentioned that as a result of the course, they were already sharing or planning to share information about S/CC topics with others; this was not at all mentioned by male students.

In addition to ILA5, teaching evaluation surveys completed by students at the end of the semester were analyzed. Of the 27 students enrolled in the course, 24 completed the teaching evaluation surveys. These surveys are filled out anonymously, so results are reported in aggregate form, without the possibility of looking at differences by gender.

The survey includes both quantitative and qualitative items. Quantitative items are mostly instructor specific, such as "The instructor presented the course in an organized manner," except for one quantitative item related to course assignments. The image below includes the quantitative student evaluations of the course. Of special note due to its specific focus on the course assignments, is the item "Assignments contributed to my understanding of the subject." The mean response for this item was a 4.67 out of a scale of 5.00, in which a value of 1.00 represents "strongly disagree" and a value of 5.00 represents "strongly agree." For this item, the breakdown in responses is: 33.33% of students responded with a 4.00 and 66.67% of students responded with a 5.00. This score indicates that students found the assignments helpful to their learning.

Summary table

Scale: strongly disagree (1), disagree (2), neutral (3), agree (4), strongly agree (5)

	Invited Count	Response Count	Response Rate	Mean	Mode	Median	SD
The instructor stimulated my thinking.	27	24	88.89%	4.58	5	5.00	0.50
The instructor was enthusiastic about teaching the course.	27	24	88.89%	4.88	5	5.00	0.34
The instructor presented the course in an organized manner.	27	24	88.89%	4.71	5	5.00	0.46
The instructor maintained an environment where students felt comfortable participating.	27	24	88.89%	4.79	5	5.00	0.41
The instructor maintained an environment where students felt comfortable seeking assistance.	27	24	88.89%	4.63	5	5.00	0.49
The instructor provided helpful feedback.	27	24	88.89%	4.58	5	5.00	0.50
Assignments contributed to my understanding of the subject.	27	24	88.89%	4.67	5	5.00	0.48
Overall of All Questions	189	168	88.89%	4.69	-	-	-

Overall effectiveness

Scale: ineffective (1), only fair (2), competent (3), very good (4), excellent (5)

Question	Invited Count	Response Count	Response Rate	Mean	Mode	Median	SD
Express your judgment of the instructor's overall teaching effectiveness.	27	24	88.89%	4.67	5	5.00	0.48

Figure 1: Quantitative student responses from end-of-semester teaching evaluation survey

Qualitative items came in the form of four open-ended questions: (1) What did the instructor do to help you learn?, (2) What could the instructor do to improve?, (3) Do you have any other information that you would like your instructor to know?, and (4) Please provide advice to future students: What could you have done to improve your learning in this course?

Responses to these questions were analyzed following the same process used when analyzing ILA5. Results for questions (3) and (4) are not included in this paper due to an insufficient number of responses for question (3), and responses not relevant to this paper, as they focused on advice to future students, which was the case for question (4).

While questions (1) and (2) were framed in a way to elicit feedback about the instructor, students often responded by describing activities/assignments that were helpful and/or enjoyable in their learning, and/or by discussing what they learned about in the course. Both questions (1) and (2) had responses from 20 students. The tables below summarize the findings from these questions. Note that the codes below are those that were mentioned by at least two students; codes mentioned by only one student were not included.

Table 3: Responses to the question (1): “What did the instructor do to help you learn?”

	Codes	Percent of respondents (n=20)	Example
Instructor-specific comment	Instructor-specific comment	40	“I like how [the instructor] is able to integrate all of the students into her classes and I wish more classes were taught in the manner she teaches.”
Comments about course activities/assignments that were helpful and/or enjoyable in their learning	Resources (videos/articles) read before class	55**	“I really loved the resources [the instructor] provided for us to read. They weren't long, but very informative and covered a lot of topics in the world of sustainability.”
	In-class discussions	25	“The class [discussions] kept me engaged in the material.”
Comments about what they learned	Learned about S/CC topics	20	“The instructor helped me to learn about sustainability, sustainable habits/practices, […], how to rethink our everyday routines in consideration of the environmental/social impacts.”
	Learned about social entrepreneurship and entrepreneurship topics	20	“[The instructor] really expanded knowledge about the business world and how much it takes to actually develop a business.”

** indicate codes mentioned by at least 50% of students.

Table 4: Responses to the question (2): “What could the instructor do to improve?”

Codes	Percent of respondents (n=20)	Example
Instructor-specific comment	15	“To improve, consider giving a master list of assignment deadlines at the start of the semester, so that students can plan their work schedules accordingly.”
Improvements in lecture, such as the use of more videos and providing additional information in class (not repeating information from resources reviewed outside of class)	20	“Some of the lectures were a little harder to stay interested in. Possibly incorporating more videos or other interactive measures.”
No improvements needed, or N/A	50**	“I personally wouldn't change a thing. 10/10 best class I took for engineering as well as the class that I learned the most from.”

** indicate codes mentioned by at least 50% of students.

The topics that were mentioned the most by students (mentioned by at least 50% of the students, and marked with asterisks in the tables above) were: (1) the resources (videos/articles) read before class were helpful and/or enjoyable to their learning (mentioned by 50% of the class), and (2) they were satisfied with the course and had no suggestions for improvement (mentioned by 50% of the class).

Discussion

This section of the paper includes conclusions regarding what has worked well and areas for improvement, recommendations for other faculty interested in implementing a similar course or incorporating these themes into already-existing courses, and students' perceptions of and learning within the course.

What worked well

As indicated in the previous section of this paper, there were several class assignments and activities that students identified both in the ILA5 and teaching evaluation surveys, as having worked well. These are:

- **The water footprint activity**. This activity may have been impactful because for many students, it may have been the first time they learned about the environmental impact of daily life choices.
- **The case studies of social enterprises**. These may have been impactful because they allowed students the opportunity to learn about actual businesses that were using entrepreneurship as a way to do some kind of social and/or environmental good. They also served as examples and illustrations of various entrepreneurship topics, such as business models and pivoting, and of best practices and what to avoid in entrepreneurial pursuits.
- **The ILAs**. These may have been impactful in part because they allowed students to tailor the assignment according to their interests, by allowing them to narrow down to topics of their choice, allowing them to learn more about something they were interested in.
- **The business plan project**. Like the ILAs, the project allowed students freedom to focus on an S/CC topic of their choice for which to create a social enterprise. In addition, this project is an example of a scaffolded activity, in which instead of writing a business plan in one sitting, there were multiple deliverables throughout the semester. These deliverables built on each other, allowing students to not only take the process of creating a social enterprise and writing a business plan step by step, but also allowing them the opportunity for detailed feedback along the way.
- **The readings/videos reviewed prior to class**. These may have been impactful because they provided a detailed introduction to each S/CC topic, provided information about potential solutions, and when applicable, provided different perspectives and viewpoints about the problem.

Students' perceptions of their learning

Students' perceptions of their learning, as indicated by a majority of student responses, is that they learned about the topics that were most emphasized in the class: they learned about S/CC topics and solutions, and they learned about entrepreneurship and social entrepreneurship. A majority of the class also indicated learning about the impact of individual actions on S/CC issues. While the role of government/policy and social entrepreneurship was always discussed in addition to the role of individual actions, it seems that the latter stood out the most to students. It is possible that in students' prior experiences, the role of policy/government in the S/CC context

has been generally discussed, but the role of individual actions rarely so, therefore potentially making this new knowledge more impactful or memorable to them. In addition, problems as large as S/CC issues can often lead to anxiety or helplessness; realizing there are ways to take action might alleviate those feelings and give a sense of empowerment.

The impact of learning about the role of individuals in the S/CC context is supported by an indication from a majority of the students that as a result of the course, they had already started or were planning/desiring to engage in taking action to address S/CC issues. For some students, this then led to giving direction to their professional pursuits, motivating them to incorporate S/CC topics and concerns into their professional goals.

A gender difference was seen in these responses, in which female students were more likely than male students to write about what they learned regarding S/CC topics, while male students were more likely than female students to write about what they learned about entrepreneurship and social entrepreneurship.

Areas for improvement

While some students provided suggestions for improving the course, no one suggestion was agreed to by a significant number of students. However, the instructor has identified some ways to improve the current version of the course:

- **For each team deliverable, require detailed information about each teammate's contribution**. To avoid team conflicts and limit the possibility of some teammates not contributing to the work, team submissions can be required to include information about each teammate's contribution, such as through the use of a Gantt chart. This can be incorporated in addition to the team peer evaluations already being conducted three times throughout the semester. Requiring detailed information about each teammate's contribution might encourage everyone in the team to distribute the work fairly.
- **Incorporate guest speakers**. Prior to the COVID-19 pandemic, iterations of this course included guest speakers throughout the semester. These were experts in entrepreneurship topics, policy, or S/CC topics who visited class to give a lecture on their area of expertise. In addition, there were also guest speakers who were founders or employees of local social enterprises, who visited class to discuss their social enterprises. These visits by guest speakers were always informative and a way for students to get additional perspectives on the topics. These visits were suspended during the COVID-19 outbreak; re-incorporating these guest speakers would improve the course.
- **Incorporate more in-class, hands-on activities**. Although not mentioned by the students in the submissions analyzed in this paper, the instructor found that in-class, hands-on activities such as the "60 minute MVP," the "How to make toast," and the transportation jigsaw activity worked very well in promoting student interaction and engagement in class, and served as great examples and applications of the relevant topics; more of these types of in-class activities would improve the course.
- **Modify the grading scheme**. The grading scheme used in this iteration of the course combines all team deliverables, including peer evaluation assignments, into one grade

category. However, these assignments have varying levels of difficulty and time needed to complete them. As a result, the grading scheme can be improved by grouping the smaller team deliverables (such as the "Background and observations" assignment and the "Planning the business" assignment) into one category, and the larger team deliverables (such as the business plan drafts) in a separate category, and assigning an appropriate weight to each.

Recommendations to other faculty

Some recommendations for faculty who already teach S/CC and/or entrepreneurship topics, or who might be considering incorporating some of these topics are:

- **Consider the use of scaffolded projects**. Scaffolded projects, with significant opportunities for feedback, can work very well: a large project becomes something more manageable to students, and the multiple opportunities for feedback result in a final deliverable of higher quality.
- **When discussing S/CC topics, consider discussing existing solutions as well, and when possible, solutions students can engage in themselves**. S/CC problems are so large, and portrayed as such in the media, that students might be led to feel helpless. Discussing existing solutions can motivate students to find ways to take action, can help bring a global problem into a local (and therefore more manageable) context, and can show engineering, STEM, and business disciplines in a positive light, as existing solutions are often the result of the application of engineering, STEM, and/or entrepreneurial skills.
- **Consider incorporating in-class and hands-on activities**. These types of activities are excellent at illustrating important topics and engaging the entire class. They also make class time especially enjoyable.
- **When teaching entrepreneurship, consider providing a brief example and/or lecture on social entrepreneurship**. This might result in interesting more students in the area of entrepreneurship, as they realize that business can be used as a force for good, and that in addition to making a profit, they can work to create social and environmental good.
- **Consider using social entrepreneurship and/or S/CC topics as contexts for projects or assignments**. Not only are social entrepreneurship and S/CC topics current and relevant topics, these are also topics that students tend to find interesting and often inspiring.

This study had some limitations. First, the ILA5 assignment specifically prompted students about what they learned about social entrepreneurship and/or S/CC topics, but did not prompt about WPs. This likely resulted in students' comments being more focused on the two former topics and not the latter. Future iterations of the ILA5 assignment can be modified to either specifically prompt about WPs in addition to the other topics, or to be entirely open ended, without specifically prompting about any of the topics. Second, due to the course having an enrollment limit of 30, and only 27 students enrolled in 2023, this means that the data analyzed in this paper is a small sample. These limitations affect the generalizability of the findings outlined in this paper; the results presented here may not necessarily be the results obtained from other, or from

larger, student populations. Further research is needed to add to the findings of this paper regarding the effectiveness of the course assignments and activities on student learning. In addition, as one of the next steps, data from future semesters of the course can be collected and analyzed to see historical trends and achievement of course outcomes over the years.

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Appendix A

The table below represents the schedule used in the spring 2023 semester. It lays out the topics taught, assignments, and deadlines used that semester.

Week#	Date	What You Will Learn/Do	Assigned	Due
1	9-Jan	• Introduction to wicked problems and sustainability	• Readings and RQs 1 (Intro to WPs and the climate crisis)	
	11-Jan	• Lecture and discussion: Intro to WPs and the climate crisis • Introduction to social entrepreneurship • Case study 1 (TOMS)	• ILA1 • Readings and RQs 2 (Intro to C2C)	• Readings and RQs 1 (Intro to WPs and the climate crisis)
2	16-Jan	Martin Luther King Day – NO CLASS		
	18-Jan	• Topics from Week 1, continued • Lecture and discussion: Intro to C2C • Water footprint activity	• Readings and RQs 3 (Policy and individual action)	• Readings and RQs 2 (Intro to C2C)
3	23-Jan	• Case study 2 (Grameen Bank) • Team introduction	• Team contract • Team1: Background and observations • Readings and RQs 4 (Food waste)	
	25-Jan	• Lecture and discussion: Policy and individual action • C2C certifications and case study (Puma InCycle) • Introduction to biomimicry	• Readings and RQs 4 (Food waste)	• Readings and RQs 3 (Policy and individual action)
4	30-Jan	• Problem identification and problem identification activity • User discovery and interviewing tips	• Team2: Customer discovery 1 • ILA2 • Readings and RQs 5 (Processed vs. unprocessed food)	• ILA1 • Team contract • Team1: Background and observations
	1-Feb	• Lecture and discussion: Food waste		• Readings and RQs 4 (Food waste)
5	6-Feb	• Lecture and discussion: Processed vs. unprocessed food	• Readings and RQs 6 (Toxins) • Peer evals 1	• Readings and RQs 5 (Processed vs. unprocessed food) • Team2: Customer discovery 1
	8-Feb	• Business model canvas, value proposition, benchmarking	• Team3.1: Business plan 1 presentation • Team3.2: Business plan draft 1	

6	13-Feb	• Lecture and discussion: Toxins	• Readings and RQs 7 (Animal agriculture and factory farming)	• Readings and RQs 6 (Toxins) • Peer evals 1
	15-Feb	• Business models, customer segments	• Team4: Planning the business	• ILA2
7	20-Feb	• Lecture and discussion: Animal agriculture and factory farming	• Readings and RQs 8 (Transportation and initiatives from different countries)	• Readings and RQs 7 (Animal agriculture and factory farming) • Team4: Planning the business
	22-Feb	NO CLASS		
8	27-Feb	• Presentations • Informal peer feedback	• ILA3 • Team5: Customer discovery 2	• Team3.1: Business plan 1 presentation
	1-Mar	• Lecture and discussion: Transportation and initiatives from different countries • Transportation jigsaw activity	• Peer evals 2	• Team3.2: Business plan draft 1 • Readings and RQs 8 (Transportation and initiatives from different countries)
9	6-Mar 8-Mar	SPRING BREAK – No class		
10	13-Mar	• Introduction to systems thinking • "Making toast" activity • Different types of WPs	• Readings and RQs 9 (Waste)	
	15-Mar	• Stakeholders • Customer relationships • Channels	• Team6: Business plan draft 2	• Team5: Customer discovery 2 • Peer evals 2
11	20-Mar	• Lecture and discussion: Waste		• Readings and RQs 9 (Waste)
	22-Mar	• The role of ethics in the climate crisis		• Team6: Business plan draft 2
12	27-Mar	• Partners, activities, resources • Costs and revenue • Introduction to legal structures	• Readings and RQs 10 (Fast fashion) • Team7: Business plan draft 3	• ILA3
	29-Mar	• Case study 3 (TerraCycle)	• ILA4	

13	3-Apr	• Lecture and discussion: Fast fashion • Case study 4 (PlayPump, Farm Truck Foods)	• Readings and RQs 11 (Consumerism)	• Readings and RQs 10 (Fast fashion)
	5-Apr	• 60 Minute MVP activity	• Team8.1: 60 Minute MVP • Team 8.2: Customer discovery 3	• Team8.1: 60 Minute MVP
14	10-Apr	• Lecture and discussion: Consumerism	• Team9: Final presentation	• Team7: Business plan draft 3 • Readings and RQs 11 (Consumerism)
	12-Apr	• Metrics, impact • Business plans	• Team10: Business plan draft 4 • Peer evals3	• Team8.2: Customer discovery 3
15	17-Apr	• Presentations • Sustainability and design		• ILA4 • Team9: Final presentation
	19-Apr	• Presentations • Additional resources	• ILA5	
16	24-Apr			• Team10: Business plan draft 4 • ILA5 • Peer evals3