Reimagining Industrial Engineering: Embedding Sustainability and Societal Impact in Course Design

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Abstract

This work presents ongoing efforts to embed sustainability and societal impact into the Industrial Engineering (IE) program at Quinnipiac University (QU). QU's strategic emphasis on sustainability aligns with its commitment to community engagement and industry partnerships, providing fertile ground for the integration of sustainability principles into academic programs.

In the Fall 2023 semester, the Lean Systems Engineering course was restructured to emphasize sustainability, integrating Lean Green examples and sustainability components throughout the curriculum. Guest speakers, including experts in Lean Green initiatives, enriched class discussions, providing real-world insights. Class activities, such as presentations and discussions, further reinforced the connection between Lean principles and sustainability goals. Additionally, a final project with a biofuel company offered students hands-on experience in streamlining sustainable processes.

Feedback from both students and the industry partner was positive, affirming the effectiveness of integrating sustainability into the curriculum. Student responses indicated a significant shift in their perception of the role of engineers in addressing environmental challenges. Statistical analysis revealed a meaningful impact on student attitudes towards sustainability.

Looking ahead, the author is spearheading initiatives to build on this momentum, including the formation of a sustainability consortium and pursuing grant opportunities to support sustainability-focused projects. The evolution of the IE curriculum at QU reflects a commitment to producing engineers equipped to address the complex challenges of a sustainable future.

Introduction

This work-in-progress manuscript discusses ongoing efforts to integrate a strong focus on sustainability and societal impact into the Industrial Engineering (IE) program within the School of Computing and Engineering (SCE) at Quinnipiac University (QU).

QU, a private institution located in the northeastern United States, boasts a comprehensive academic structure encompassing nine distinct units, including SCE. Notably, sustainability features prominently in QU's strategic plan [1][2]. A dedicated sustainability committee drives various campus-wide initiatives, and an annual Sustainability Report communicates progress within the community. QU has garnered recognition for its sustainability endeavors, aligning well with its strategic plan's third pillar: "Nurture and positively impact internal, local, and global communities." This emphasis on community engagement harmonizes with QU's growing commitment to industry partnerships with regional companies, extending to its academic units.

SCE, a hub for engineering and computing programs, places a strong emphasis on practical, hands-on education. Collaborative ventures with industry partners are integral, fostering real-world learning experiences and often providing financial support. Additionally, SCE places significance on multidisciplinary work and is actively establishing an undergraduate research framework. Approximately 200 students are enrolled in the four undergraduate-only engineering programs.

The IE program at QU, consisting of 45 students, follows a project-based curriculum where each IE course culminates in a real-world project. Over a 15-week semester, students engage in hands-on learning during the first 12 weeks, followed by two weeks dedicated to final projects involving client site visits. In the 15th week, students present their analyses and recommendations, forwarding the final report to the industry partner.

The alignment of the university's strategic emphasis on sustainability, community impact, and industry partnerships with SCE's collaborative approach sets the stage for an innovative sustainability-themed IE program. The vision entails collaborating with a network of industry partners specializing in clean energy and the circular economy, marking the initial step toward realizing this vision.

Method

This section describes the work conducted in the Fall 2023 semester. During this time, the Lean Systems Engineering course, a core requirement for IE juniors and a technical elective for Mechanical Engineering students, underwent a transformation. Typical Lean Manufacturing courses focus on improving operational performance, not focusing on the triple bottom line of Sustainability: economic growth, environmental preservation, and social responsibility [3][4]. The Lean Systems Engineering course at QU IE was no different and had previously only focused on operational excellence. This year, the instructor restructured the course to emphasize sustainability. This endeavor was aligned with general trends where performance is considered from a multidimensional point of view that also accounts for environmental and social impacts [5].

As much as possible, Lean Green examples were used to complement the explanation of the various concepts of Lean. In addition, many sustainability components were added to the course throughout the semester, including guest speakers, class discussions, reflections, presentations, case studies, and a final project.

Guest Speakers

Dr. Geandra Queiroz and Mr. Brion Hurley have been very active in Lean Green. Dr. Queiroz was a guest speaker in two classes. During the first visit, she discussed Lean Green at a high level and introduced the pertinent facts of one of her previous projects. The project involved sustainability initiatives of the Canadian operations of a large multinational automobile manufacturer headquartered in Europe. During her second visit, she went through the details of the case, discussing the analysis and recommendations. Student teams had an assignment during the two weeks in between her visits. In addition to Lean-specific concepts, the assignment had cultural and global elements as well. It asked for research into the European Union’s 2050 long-term strategy compared to environmental policies of the United States, Canada, and Australia. The assignment prompt is presented in Appendix A-1.

Mr. Hurley was a guest speaker in one class, discussing a project he had undertaken with a furniture company. As a result of his Lean project, the company’s usage of wood had been reduced very significantly. His presentation was in the context of Lean Green’s goal of reducing the usage of virgin raw material. A team-based assignment stemmed from the presentation. The

students had to submit a reflection discussing their main take-aways, Lean techniques used, and sustainability goals achieved. This assignment prompt is presented in Appendix A-2.

Class Discussions

Prior to each class, there was a lesson guide posted for the students. Each lesson guide outlined the lesson objectives, as well as any videos to watch or articles to read. The assigned videos and readings either served class discussions for the first few minutes of class or supported a concept introduced during the lesson. Some of the videos focused entirely on Lean tools, such as 5S and visual management; others also served to demonstrate Lean Green concepts. As an example, when introducing Continuous Improvement, an assigned video covered a Lean-based project to reduce the usage of water in producing jeans pants. The students discussed this video when the concepts of standardization and reducing non-value added activities were introduced. As an example of using sustainability examples for explaining concepts, when explaining KPIs, energy usage was cited as a performance indicator to track.

Presentations

There were two presentations performed during the semester. One was done individually; the other done as a team. For the individual presentation, students had to choose an article of their choice, 2010 to present, from one of two journals: *Cleaner Production* and *Sustainability*. For the majority of the students, this was the first time they performed a literature review on scientific journals. Each student recorded a short video, discussing the article's relevance to Lean concepts, as well as the usage of Lean techniques to improve sustainability-related metrics in the project tackled. In a Discussion Board-style, each student also had to provide feedback on the presentation of at least two other students. This assignment prompt is presented in Appendix A-3.

For the group presentation, each student team was asked to create a presentation based on two assigned videos, focusing on Lean Green. The 23 students were in teams of 4 or 5. The presentation asked the teams to discuss their main take-aways, identify main Lean principles and techniques used, how Lean Green benefitted the organizations in both efficiency and sustainability, and the broader impact of Lean Green initiatives on the environment and society. This assignment prompt is presented in Appendix A-4.

Final Project

During the Fall semester, the instructor approached Quantum BioPower for a potential course project and received a very enthusiastic response. Quantum BioPower is an anaerobic digestion facility that receives bad produce, expired food and beverage, and other organic waste, turning it into a sludge, before feeding it into a digestion tank. The resulting biofuel can then be used to generate electricity or natural gas. A project was defined to streamline the process from when material is received to when it is fed into the machine that turns it into sludge.

The instructor had a preliminary meeting with the Vice President of Operations of Quantum BioPower, discussing the details of the project and taking some videos of the de-packaging building. He then dedicated a part of a class to go over the details of the project and share his insights while showing the video.

As stated in the Introduction section, weeks 13 and 14 of IE courses are spent on visiting the client site, collecting data, making observations, and interviewing the stakeholders. Prior to week 13 of this Lean course, student teams worked out the logistics to have small teams of five – one representative of each team – visit the company. Safety and not interfering with the ongoing operations necessitated the small size of the visiting teams. A point of contact was identified by the company, and he had set aside some dedicated time to spend with the visiting teams. Early in week 15, student teams performed an oral presentation. I provided them some feedback which they incorporated into their final report due by the end of the week.

Results and Next Steps

This section initially describes the results from the client's perspective and the students' perspective. It goes on to discuss the next steps planned by the author.

Client Feedback

In January, the company Vice President of Operations responded to the instructor with an extremely positive response. He stated that after going through the reports, the level of detail and the quality of the recommendations exceeded his expectations. He thanked the instructor for choosing to work with Quantum BioPower for this project. In addition, he expressed an interest in learning how they may work with QU in the future to continue to refine their process in their de-packaging building.

Student Feedback and Performance

During the three course assignments, there were numerous positive comments from the students. A sample student response for each relevant assignment prompt is displayed in Appendix B. It should be noted that there was not a single negative comment about integrating sustainability into the course.

Prior to the start of the semester, the students were asked to submit an entry to a Discussion Board. One question was the following: "Do you think as engineers, and specifically as Industrial Engineers, we can play a role in positively affecting the environment?". This pre-post survey mirrored the approach employed by Watson and Zhang in their educational research [6]. At the semester's conclusion, the same question was posed to students again, eliciting responses from nine out of the 23 participants. Evaluation of student responses was conducted using a rubric, a methodology consistent with established practices in educational research [7]. Drawing inspiration from Ercikan and McCaffrey's work on the integration of artificial intelligence into rubric generation [8], the author utilized ChatGPT to construct the rubric. Additionally, similar to the framework outlined by Cooper [9], ChatGPT was employed to systematically apply the rubric and assess student contributions.

A one-tailed t-test was then performed on the total before and after scores of the students. A p-value of 0.0008 and Cohen's d value of 1.57 to conclude that the course suggest that the course had a significant and practically meaningful impact on the students. The rubric and the results are presented in Tables 1 and 2. While the number of respondents is small (n=9), the trend is certainly positive, encouraging the continuation of integrating sustainability into the IE curriculum.

Table 1: Criteria for scoring responses

1. Understanding (0-5 points):
   - 0 points: No understanding or awareness of the role of engineers in environmental impact.
   - 1-2 points: Limited understanding, vague or inaccurate notions.
   - 3-4 points: Some understanding but lacking depth or specifics.
   - 5 points: Demonstrates a clear and comprehensive understanding of the role of engineers in positively affecting the environment.
2. Relevance (0-5 points):
   - 0 points: Response is completely irrelevant to the question.
   - 1-2 points: Response is minimally relevant or loosely related.
   - 3-4 points: Response is somewhat relevant but lacks a strong connection to the question.
   - 5 points: Response is highly relevant and directly addresses the question.
3. Clarity and Articulation (0-5 points):
   - 0 points: Response is incoherent, unintelligible, or lacks any structure.
   - 1-2 points: Response is unclear, poorly organized, or difficult to follow.
   - 3-4 points: Response is generally clear but may lack some organization or structure.
   - 5 points: Response is exceptionally clear, well-structured, and easy to understand.
4. Depth of Insight (0-5 points):
   - 0 points: Response lacks depth or insight, providing only surface-level observations or opinions.
   - 1-2 points: Superficial insights, limited elaboration.
   - 3-4 points: Some depth of insight, with reasonable elaboration.
   - 5 points: In-depth insights provided with thorough explanation and examples.
5. Change in Perception (0-5 points):
   - 0 points: No change in perception or awareness before and after the course.
   - 1-2 points: Minimal or unclear change in perception.
   - 3-4 points: Some noticeable change in perception demonstrated.
   - 5 points: A clear and significant change in perception evident in the response.

Table 2: statistical analysis of before-and-after scores

Student #	total "before" score	total "after" score	p-value, 1-tailed paired t-test	Cohen's d for effect size
1	19	22	0.00078	1.57
2	17	24		
3	21	21		
4	16	21		
5	16	21		
6	19	23		
7	25	25		
8	16	21		
9	21	25		

Figure 1 may better visualize Table 2. The non-linear and linear lines represent the students' responses and trendlines, respectively. Comparing the upper and lower linear trendlines clearly shows the overall improvement of the students' knowledge and perception regarding IE roles in sustainability.

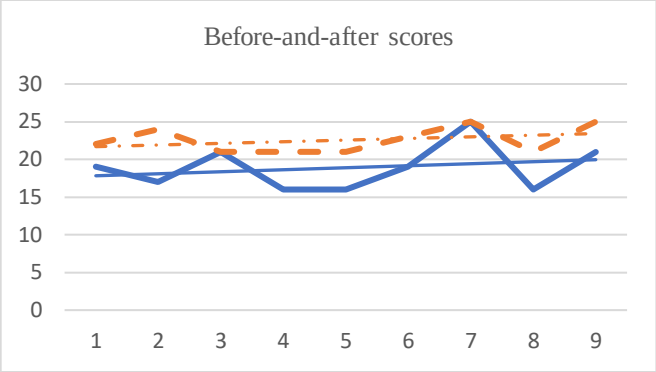

Figure 1: Pre-post assessment of student knowledge and perception of IE roles in environmental sustainability

Moving forward

The author is pursuing several endeavors to build on last semester's momentum, continue to add more sustainability and societal impact in his future courses, to teach a new course – Industrial Ecology – in Spring 2025, and to scale this effort up for the IE program.

Sustainability Consortium

The author has proposed the formation of a sustainability consortium to foster responsible business and economy in the state. The consortium comprises an academic hub and an industry network focused on clean energy and circular economy. During the author's collaborations with Quantum BioPower, the company vice president concurred with the author's belief that the consortium can address a market gap. Within QU, the author has established a cross-disciplinary academic hub with five faculty members in Industrial Engineering, Mechanical Engineering, Environmental Science, Environmental Policy, and Management and Strategy. In the model envisioned, consortium members pay an annual fee, gain access to subject-matter experts, bring forth their pain-points, and get their challenges addressed. Undergraduate students work with the faculty to receive experiential learning opportunities in social responsibility and honing their technical skills. These projects support SCE's Undergraduate research framework. Overall, more engineering courses will have sustainability-based final projects and case studies. The five members of the consortium's academic hub have already started their bi-weekly meetings from the start of the Spring semester. The team is now working on identifying potential consortium members and the best way to approach them.

Grants

The author has submitted a proposal to ASEE's Engineering for One Planet mini-grants program. This proposal focuses on the creation of the aforementioned Sustainability Consortium. The author is considering other foundation grants that value the integration of sustainability in engineering curricula. Lastly, the author is working with a colleague from QU's College of Arts and Sciences (CAS) to submit an application for a Fulbright Scholar-In-Residence (S-I-R). The application asks Fulbright S-I-R with expertise in sustainability.

Upon a successful outcome, the Fulbright S-I-R will teach two courses in engineering and two in CAS's Environmental Sciences program.

Evolution of the QU IE curriculum

There are 15 IE courses, including four technical electives. Incorporating sustainability into most of them will not be difficult. Only the two Human factors courses may pose a challenge. In terms of change management, the IE faculty is enthusiastic about integrating sustainability into the IE program, especially as the advanced manufacturing and Industry 4.0 themed are strengthened across the program. The author is aware that change takes time and is patiently building on the momentum, aiming to do more each semester. however, the vision is to do good while building an IE program whose distinctiveness is its emphasis on sustainability.

Conclusion

The integration of sustainability principles into the IE program at QU represents a significant step forward in preparing engineers for the challenges of a rapidly evolving world. Through a strategic emphasis on sustainability, QU has demonstrated its commitment to fostering community engagement and industry partnerships, providing students with unique opportunities to make a positive impact.

The Fall 2023 semester saw the Lean Systems Engineering course undergo a transformation, with sustainability at its core. By integrating Lean Green examples and sustainability components throughout the curriculum, students gained valuable insights into the intersection of engineering and environmental stewardship. Guest speakers and class activities enriched the learning experience, reinforcing the connection between Lean principles and sustainability goals.

Feedback from students and industry partners has been positive, indicating the effectiveness of the curriculum redesign. Students' perceptions of their role as engineers in addressing environmental challenges have shifted significantly, reflecting a deeper understanding of their potential impact on society.

Looking ahead, QU's IE program is poised to build on this momentum through initiatives such as the formation of a sustainability consortium and pursuit of grant opportunities. By continuing to prioritize sustainability in the IE curriculum, QU will produce engineers equipped to tackle the complex challenges of a sustainable future.

References

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6. Watson, J. and Zhang, Y. (2021). A Retrospective Pre-Post Survey to Analyze Course Revisions, Perceived Learning, and Learning Outcomes in an Agricultural Structures Course. *Transactions of the ASABE*. 64(5): 1415-1423.
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9. Cooper, G., (2023). Examining Science Education in ChatGPT: An Exploratory Study of Generative Artificial Intelligence. *Journal of Science Education and Technology*, 32, 444–452.

Appendix A, Assignment Prompts

Appendix A-1, Assignment 1

On Tuesday, October 3rd, Dr. Geandra Queiroz visited us virtually to discuss a case of an automotive manufacturer. The following is the link to her presentation:

- link to Dr Queiroz's presentation

The file containing her slides is also provided on Blackboard (titled "Dr. Geandra Queiroz's presentation" as a pdf).

In this team assignment, you will submit a report that discusses the following prompts:

- Did you learn anything new about Lean Green from this presentation?
- Based on Dr. Queiroz's presentation, identify challenges and opportunities for this automotive company.
- Based on the presentation, identify current strengths, things that the company is doing well.
- Perform some comparative research into environmental policies. What does the European Union's 2050 long-term strategy entail, and how does it compare to environmental policies of the United States, Canada, and Australia?
    - What aspects of each policy stand out to you the most and why?
    - On the international scale, Canada and the United States are similar in many ways. Are the environmental policies of these two similar and neighboring countries similar? Pick any one of the main Canadian initiatives that you think would be difficult to implement in the United States. Discuss your reasons for this perceived difficulty.

By 11:59pm on 10/16, each team should upload their write-up to Bb. Assignments submitted after the due date, but before noon on 10/17 will receive a 20% penalty. Assignments submitted after noon on 10/17 will receive a zero grade. This is because Dr. Queiroz will delve deeper into the details of the case, providing answers to the first three bullets of the assignment.

Appendix A-2, Assignment 2

On Tuesday, November 7th, Mr. Brion Hurley visited us virtually to discuss the case in the construction industry. The following is the link to his presentation:

- link to Mr Hurley's presentation

In this ***individual*** assignment, you will submit a reflection by 11:59pm on 11/29, discussing the following prompts:

- Share the most significant lessons or insights you gained from Mr. Hurley's presentation. What stood out to you as particularly valuable or innovative in terms of Lean Green practices?
- What additional information would you like to know about the case? Why?
- Draw connections between Mr. Hurley's case and the fundamental concepts of Lean manufacturing that you've learned in class. How did this real-world example align with the principles of Lean.
- Reflect on how the Lean techniques discussed contributed to sustainability goals. Specifically, consider how the reduction in scrap wood usage impacted the environment, resource conservation, and waste reduction.

Appendix A-3, Research-based Oral Presentation

For this assignment, students first conduct the necessary research and then present their findings (***individually***) in a recorded video. The videos are to be posted on Bb by 11:59 pm on 10/23/23. Each student will post their video on the discussion board. This allows other students to provide feedback to classmates.

In addition to posting a presentation, each student must provide their thoughts on the presentation of at least two other students. The posting must be meaningful and refer directly to the content of the video, including take-away messages. Your posting should signal to me that you actually watched the presentation carefully.

Source: you can select any articles from the following two journals: "Cleaner Production" and "Sustainability". Both journals are available at the library. If you've never conducted research using scientific journals, you'll likely need the help of one of the librarians. One of the librarians, Ms. Janet Valeski, has recorded a tutorial on conducting a literature review: https://qu.yuja.com/V/Video?v=8827229&node=38167813&a=26495241&autoplay=1
Please note: you can choose any article that captures your attention, as long as it is from 2010-present.

Content: your presentation will focus on the following:

- A high-level summary of the article and its findings.
- Relevance to Lean concepts we have learned together. How did the authors use Lean techniques to improve sustainability-related metrics in the project they tackled?

Length: your presentation will be around 4 minutes (+/- 30 seconds). This is just long enough to put forth a technical discussion and share your main takeaways.

Material: you have the choice of showing slides/diagrams, but you don't have to. A presentation that is delivered 100% verbally is perfectly fine. Use visual aids only if it helps you convey the information better.

Medium: you can create your video by recording yourself on zoom, YouTube, or any other medium of choice.

Appendix A-4, Oral Presentation based on Assigned Videos

The following videos were assigned to you:

- https://www.youtube.com/watch?v=-aDFKeAcxQQ 4:12 to 15:04
- https://www.youtube.com/watch?v=jT858zCTOHI from start to 5:10, 15:58-41:50

This assignment asks each team to create a presentation based on these two videos. The objective of this team presentation is to bridge the gap between classroom theory and real-world Lean Green applications. This exercise will help you better understand how Lean principles can be leveraged to achieve sustainability goals in various industries.

Here are some prompts for you to consider as you create your presentation:

- You can discuss your key takeaways from the videos. If you choose to do this, it should be no more than two minutes.
- Identify and explain the key Lean principles or techniques that were applied in the case studies presented in the videos. Obviously, you can only comment on Lean concepts that you've been exposed to in the course thus far.
    - How were these Lean principles adapted or extended to address sustainability goals, such as reducing carbon footprint, energy expenditure, or raw material usage?
- How did Lean Green initiatives benefit these organizations in terms of both efficiency and sustainability?
    - Share data and statistics from the videos regarding the measurable improvements achieved through Lean Green practices (e.g., reduced waste, energy savings, reduced emissions, cost reductions). Discuss the significance of these results.
- Consider the broader impact of Lean Green initiatives on the environment and society. How do these initiatives contribute to sustainability beyond the organization's walls?
- Reflect on your personal insights and takeaways from the videos. What aspects of Lean Green resonated with you the most, and why?
- I've posted an evaluation rubric that will be used for grading purposes. You should consult this rubric as you design your presentation. The weight of the grade should determine your focus on the bullet points above.

You will present during class on Tuesday, September 26. I will complete the evaluation rubric, and I will ask a representative of each team to also complete a rubric for each team's presentation. This will add a peer element to grading.

By 11:59pm on 9/26, each team should upload a copy of their presentation to Bb.

Appendix B, A Representative Sample of Student Responses

Prompt	Student Response
Assignment 1, oral presentation on two Lean Green videos. "Consider the broader impact of Lean Green initiatives on the environment and society. How do these initiatives contribute to sustainability beyond the organization's walls?"	Enhanced Corporate Social Responsibility: 1) Enhancing the social and environmental impact of Companies; 2) Sustainable business practices; 3) Ethical management; 4) Responsible sourcing of materials. Resource Efficiency: 1) Sustainable development; 2) Environmental sustainability; 3) waste reduction. Influence on Others: 1) Inspiration to consumers/communities; 2) Competition for other organizations; 3) Positive media presence.
Assignment 1, oral presentation on two Lean Green videos. "Reflect on your personal insights and takeaways from the videos. What aspects of Lean Green resonated with you the most, and why?"	Planet, profit, people: Environment, social, economic elements are interrelated and need to be improved as a system. Collecting data and measurements: Identifies waste in systems, understanding patterns, shows ways to improve. Continuous improvement: Is a continuous journey, Adjust and adapt to new processes
Assignment 2, guest speaker Dr. Queiroz. "Did you learn anything new about Lean Green from this presentation?"	First, I learned that lean can be a huge driver towards sustainability. Within this presentation, the environment was the 3rd competitive priority for the company. In business and strategic management, the term "competitive priority" refers to the strategic emphasis a company places on certain aspects of its operations to gain a competitive edge in the market. Lean can contribute to many aspects of the company enabling them to do this, in which the company specifically made multiple improvement, examples being; the lighting of the factory facilities, using cleaner technologies, integrating human resources to include environmental aspects, as well as quality management. Therefore, this company places a large emphasis on sustainability and responsibility, which uses lean as a driver towards these goals. Another point learned is that being Lean does not necessarily mean being green. Being lean and being green refer to two different concepts: efficiency and environmental sustainability, respectively. There is an overlap in the two areas, but they each have their own distinct focuses. Being lean means optimizing the process to reduce waste, improve efficiency, and overall improving productivity. There is a heavy focus on mostly on reducing costs and time while keeping quality high. Being green means minimizing the negative environmental impact of producing products. Its main focuses are reducing the consumption of resources, minimizing pollution, and integrating the use of sustainability. However, lean and green can be implemented together to identify and eliminate waste in the process, minimize energy conservation, optimize materials and recycling, and contribute to continuous improvement for sustainability.
Assignment 2, guest speaker Dr. Queiroz. "Perform some comparative research into environmental policies. What does the European Union's 2050 long-term strategy entail, and how does it compare to environmental policies of the United States, Canada, and Australia? What aspects of each	Most of the other countries seem to have similar goals, which logically makes sense because of two reasons: 1) it takes a team effort to accomplish the lofty goals set to help our environment and 2) it socially may look bad to not support the same goals as other countries. Therefore, the major goal of net-zero greenhouse gas emissions by 2050 acts as almost an umbrella goal. However, some differences can be found in how each country plans to reach the objective and other details of their policies.

policy stand out to you the most and why?"	To start, the environmental policies of the United States, who rejoined the Paris Agreement in 2021, are focused a lot on the economy and climate change. In conjunction with standards set by the Paris Agreement, the US released its Nationally Determined Contribution, which sets the goal to have a 50-52% reduction (as compared to 1990 data) in greenhouse gas emissions by 2030 (3). This is the first step in the process of reaching net-zero by 2050 and maintaining the global temperature. Additionally, the US launched the Global Methane Pledge. Methane is a big contributor to the increase of global temperature, with some sources saying that it is responsible for 0.5 degrees Celsius of the 1.0 degree Celsius recorded warming (3). Overall, the US states that their plans to reach their goals include adjusting current agricultural systems, reducing deforestation, reworking the global economy in terms of energy, and removing carbon dioxide (3). Five key points were discussed: 1. increasing clean electricity, 2. utilizing other clean fuels, 3. figuring out ways to decrease how much energy is necessary, 4. lessening emissions of methane, and 5. increasing the amount of carbon dioxide removed from the atmosphere. Next, in Canada, their plan, "A Healthy Environment and a Healthy Economy", combines the goal of creating more jobs while also placing importance on climate action and making life more affordable. Canada specifically cites the goal in their Nationally Determined Contribution (in accordance with the Paris Agreement) to have at least a 30% reduction (as compared to 2005 levels) in greenhouse gas emissions by 2030. Five pillars of the plan set the tone for change: 1. reducing energy consumption directly impacts the affordability of life, 2. increasing the opportunities for clean transportation, 3. utilizing carbon pricing to ensure pollution isn't free, 4. focusing on internal industrial policies, and 5. protecting nature, while also using it as a means of fighting climate change (4). More in-depth research on carbon pricing revealed it as a policy introduced in Cananda in 2019 that places a fee on products and services that emit carbon. Carbon pricing puts the responsibility of the cost of climate change on the producers of greenhouse gas emissions (5) It was noted that this procedure should benefit not only the environment, but also the Candian population because money collected will be used to help invest in other measures to reduce emissions and reward the people that show initiative to make environmentally sound choices (Climate Action Incentive payments) (4). Lastly, in Australia, environmental policies are related to something called "the Plan" (Australia's Long Term Emissions Reduction Plan) (6). It places more emphasis on using technology to achieve the goal of net-zero emissions, specifically using the "Technology Investment Roadmap" to dictate the process. There is a clear focus on improving environmental conditions, while also maintaining the current job and industry opportunities. Similar to the US and Canada, Australia also identified five key principles of their initiatives: "technology not taxes; expand choices not mandates; drive down the cost of a range of new echnologies; keep energy prices down with affordable and reliable power; and, be accountable for progress" (6). These are different ideals, partially because they make the claim for no additional taxes,

	and it seems to be more accommodating instead of limiting. With specific focus on technology, Australia aims to continue its world lead in high use of renewable energy, while continuing to advance new and emerging strategies. Policy Standouts For the EU policy, it is blaringly obvious from the first minute of looking over the policy that the goal of net-zero emissions will face many challenges, but it is achievable. I appreciated their broad approach; there is not just one single industry that can be targeted, but instead, all sectors (power, industry, agriculture, buildings, etc.) have a role to play and must be improved (1). It also seems like in general, the change is going to be expensive. The United States' policy shared the call to action that was apparent in the EU policy, while also adding a more personal touch. The US was comprehensive in their goal setting but had more of a focus on the general goals and was not specific from state-to-state with what must be accomplished. This may be a feature of our government's style, as compared to the other countries. One of the aspects that stood out the most was the focus on methane, because it was directly stated and explained the most. Canada directly addressed the role of the government in their plan, sharing that since they are the largest public purchaser of goods and services, the change must start with them (4). Another point that stood out from Canada's policy description was their connection with being a global producer of hydrogen, a resource that could play a large role as a clean energy source (4). Canada also seemed to promise change for everyone, not just specific locations or groups. Australia's focus on the people as well as the environment stood out. Not only did they emphasize and sell it as helping the environment, but also bringing more prosperity to the economy. I was impressed with their statistics on current renewable energy usage, and how they only want to keep improving that. Australia seemed to focus the most on technology and how advancements were one of the best ways to accomplish their environmental goals.
Assignment 2, guest speaker Dr. Queiroz. "On the international scale, Canada and the United States are similar in many ways. Are the environmental policies of these two similar and neighboring countries similar? Pick any one of the main Canadian initiatives that you think would be difficult to implement in the United States. Discuss your reasons for this perceived difficulty."	The environmental policies of Canada and the United States have similarities and differences. The Canadians seem to go a little bit more in-depth with their initiatives and have already taken action to set change in motion. On the other hand, the United States seem to have slightly less direction and place more focus on the big goals (lessening greenhouse gas emissions & the global temperature), but less on the little things. Both countries mention how helping the environment will also help their people. However, when comparing the five key principles of the US versus Canada, there is a clear difference in how the Canadian initiatives were created to directly have a positive impact on the population. In general, the Canadian policies also place focus on industry and its impact on emissions, while the US looks more at emissions from power generation. One main Canadian initiative that would be difficult to fully implement in the United States would be carbon pricing. A few reasons come to mind when considering why it may be arduous to enact a similar policy in the US, including the difference in population (size, ideals, lack of connectedness, potential pushback), political beliefs, and its perceived impact on the economy. To start, as of July 1, 2023, the recorded population of the United States was about 335.0 million people, and

	the count of Canadians was about 38.5 million (7). This is a very large difference, and it is a factor that influences environmental issues and politics. It is harder to convince a larger group of people to all strive for the same goal, or to at least agree that there is a problem that needs attention. In the United States, it seems like even more of a struggle to unite the population across divides, whether they be politically motivated or of some other sort. Even now, twelve states already do have a version of a carbon pricing system in which financial incentives are offered for reducing emissions of greenhouse gases, but there is no full country policy (8). Additionally, there are concerns that carbon pricing could have a negative impact on lower income areas (9). Pushback could come from these communities, and also from industries that fear the tax may harm their businesses in a way they could not bounce back from. Canada's success with reducing emissions seems to have partially been from their addition of carbon pricing to their policies, however, this positive feedback might not be enough to convince Americans that the same steps should be taken in their country.
Assignment 3, guest speaker Mr. Brion Hurley. "Share the most significant lessons or insights you gained from Mr. Hurley's presentation. What stood out to you as particularly valuable or innovative in terms of Lean Green practices?"	Something that stood out to me that was particularly valuable/innovative in terms of Lean Green practices would be when Mr. Hurley mentioned how he reduced wood waste. In his slides, he showed the before, which was sixty-six linear feet of wood waste, and how they were all tossed away in industrial sized bins, but after his implementations of Lean Green practices, it was reduced to five linear feet of wood waste and were all disposed of into small bins. To me, this was valuable since this is a combination of purchasing new equipment, mistake proofing, and creating clear guidelines on how to utilize scarp wood pieces. As an Industrial Engineer, I enjoy working with budgets and seeing the costs slowly get reduced and being environmentally aware is always great.
Assignment 3, guest speaker Mr. Brion Hurley. "Reflect on how the Lean techniques discussed contributed to sustainability goals. Specifically, consider how the reduction in scrap wood usage impacted the environment, resource conservation, and waste reduction."	It is becoming consistently clearer how Lean and Green go hand in hand. Mr. Hurley did a great job highlighting the relationship in this case. One of the first things that came to mind when I was reflecting on his presentation was the picture and value comparison of the reduced wood waste the company saw after implementing Lean techniques. Going from 66 linear feet to a mere 5 linear feet is a huge reduction, and it is something that adds up quickly. By using less wood and having less go to scrap, the company was saving material, time, and energy. Saving material is directly related to sustainability because the less that is needed by the company, the less that they need to purchase, and the less that needs to be made by the supplier. Energy also relates to sustainability because it takes energy to power the buildings that the wood is stored in and the machines that are used to work with the wood. Additionally, if the company did not need to rework or scrap something, then the time and energy they had already spent on it up to that point would not be wasted. In general, having less scrap material meant that the company was being more deliberate with the actions they were taking, and they were not wasting good material. Lastly, as Mr. Hurley mentioned, the quality of wood decreases over time, so it was important to figure out a way to lessen the inventory and reduce the amount of wood that would need to be thrown out just because it was not of good enough quality.