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Discovering Sustainability Practices In Research And Innovation Sites

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DISCOVERING SUSTAINABILITY PRACTICES IN RESEARCH AND INNOVATION SITES (PRACTICE)

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ABSTRACT

This practice paper is a descriptive account of an experience with a sustainable development learning project for engineering students in a Science, Technology and Society (STS) course at Bilkent University. The students participated in the STS Sustainability Awards competition for two semesters in one academic year, an event that was inspired by Bilkent University's 2021–2022 Sustainability Year. As part of the project, the students found a company or laboratory, consulted them on their innovation practices and asked questions that were grounded in Responsible Research and Innovation (RRI) approaches. RRI can provide an opening for students to explore how various values, including sustainability and privacy, are considered in innovation practices. The values by design approach can help engineering students to see that innovators consider both instrumental and qualitative values during the innovation process. Although the project has been used in other years, the sustainability awards motivated students to explore how innovators respond to concerns around a range of sustainability issues. The award recipients produced projects on smart homes, nanotechnology-based solar panels, clean meat, industry 4.0, geothermal energy, air cars and magnetic resonance imaging technology, and gave presentations in events hosted by the Faculty of

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Engineering administrators. Although future research in this area is needed, applied learning experiences, such as the one that is described in this paper, could have the potential to help bridge the disciplinary divide between STS and engineering.

1 INTRODUCTION

1.1 Crossing the Disciplinary Divide

Although engineering students are required to take Science Technology and Society (STS) classes or other classes focused on social, ethical and environmental contexts, they are not always sure why these subjects are part of the curriculum. Engineering students do not always appreciate the practical value of applying social knowledge or ethical approaches. Newberry suggests that students often perceive learning about ethics to be a trivial and useless pursuit, partly because they do not generally see their engineering professors respond to ethical issues (2004, 347). This may be part of the reason that engineering students view societal concerns as "strictly ornamental" (Newberry 2004, 350). Likewise, Cech suggests that although engineering students often start out with a desire to solve societal problems or grand challenges, they typically concentrate on math and science during their first two years of training and this focus may take them away from the societal context culminating in the "culture of disengagement" (2014).

The apparent disconnection between social and technical knowledge among engineering students is an issue that could be addressed through applied projects and the inclusion of social values in engineering classes. It may be helpful for engineering students to receive approval from technical professors for the work that they do on social and environmental projects. Foley and Gibbs suggest that in order for engineering students to take the ethical dimensions of engineering seriously, their efforts in this area must be acknowledged by instructors and institutional administrators (2019, 13). For these reasons, it is important to introduce students to social and ethical issues that come up in the innovation process in a way that allows them to receive recognition for their work on sustainability practices from the engineering faculty in which they are trained. It is also essential to encourage students to engage with innovators, so that they can see how social and environmental values are managed in an applied context.

1.2 Applied STS Projects at Bilkent University

The STS course at Bilkent University is supported by the Faculty of Engineering. It has been managed by the Faculty of Engineering for over twenty years and was originally introduced by Haldun Ozaktas, a Professor in the Department of Electrical and Electronics Engineering (Ozaktas 2013). The main role of the 2-credit course is to respond to Accreditation Board of Engineering and Technology (ABET) goals through addressing social, ethical and environmental values. The course is currently taught by instructors with expertise in Science and Technology Studies and we ask students to engage with innovators for their term projects. Students can use different theoretical approaches, including responsible innovation, social construction of technology and actor network theory. The students typically use interviews to consult the innovators on their innovation practices, but they can also use field notes or website scans.

The STS Sustainability awards competitions were introduced in 2021 and 2022 as part of a larger institutional sustainability initiative (Bilkent University n.d.). The sustainability awards motivated students to explore how innovators respond to concerns around a range of sustainability issues using a responsible research and innovation (RRI) approach. The students identified an innovation site and conducted interviews with engineers at the site. The jury came from several different departments, including urban design, industrial engineering, education and electrical engineering. The jury awarded STS Sustainability Awards to projects that were clearly focused on sustainability, including clean meat, geothermal energy and nanotechnology-based solar panels. They also gave awards to projects that discovered sustainability practices or envisioned future sustainable technologies in the area of smart homes, industry 4.0, air cars and magnetic resonance imaging (MRI) technology. The STS Awards provided an opportunity to showcase STS student work in a formal auditorium setting. The events were hosted by the Faculty of Engineering administrators (Science Technology and Society n.d.). Through conducting RRI studies, the students discovered how a range of values, including sustainability, may be included at an early stage in the innovation process.

2 ENGAGING ENGINEERING STUDENTS IN SOCIAL AND ENVIRONMENTAL ISSUES WITH RESPONSIBLE INNOVATION

2.1 RRI: Beyond Corporate Responsibility

Responsible Research and Innovation (RRI) approaches provide an opening for students to explore how various values are considered in innovation practices. The values by design approach can help engineering students to understand that both instrumental and qualitative values can be included during the innovation process (van de Poel 2015). The social values may include gender inclusion, stakeholder concerns, user experience, privacy and environmental aspects. One of most cited RRI definitions demonstrates that the approach incorporates both economic and social contexts, in addition to tangible outcomes:

> Responsible innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other regarding the ethical acceptability, sustainability and social desirability of the innovation process and its marketable products. (Von Schomberg 2013, 63).

RRI has also caught the attention of industry, which is an indication that it can be useful in an applied context and, for this reason, should be of interest to engineering students (EIRMA n.d.). For example, several Horizon 2020 projects focused on how to assess RRI in industry (van de Poel et al. 2020; Responsible-Industry n.d.). This practical dimension also has applications in engineering education. For example, RRI approaches can be helpful for problem-based learning, partly because it provides a lens for examining responsiveness and solutions (Conley, Tabas and York, 2022; Stilgoe, Owen and McNaughten, 2013).

Sustainable development and responsible innovation intersect in many ways and provide methods and opportunities for both engineering educators and industrial

actors to include social and environmental values. As a concept, sustainability has been embraced by industry and environmentalists, even though these stakeholders often have different understandings of the term (Robinson, 2004). However, these differences provide flexible opportunities for the inclusion of various values. The Brundtland report called for sustainability assessment tools to be further developed at an early stage, but they remain notoriously difficult to implement: “[T]he tools for monitoring and evaluating sustainable development are rudimentary and require further refinement” (Brundtland 1987, 256). Indeed, corporate strategies have not always developed in complete alignment with the Brundtland report (Barkemeyer et. al. 2014. 28). Although innovators have had corporate social responsibility (CSR) strategies in their company objectives for some time, it is difficult to standardize measurements (van Marrewijk, 2003; Contrafatto and Burns, 2013, 359). Much like sustainability, responsible innovation is a flexible concept that includes a focus on economic aspects, innovation and social and environmental issues (Guston, 2015). Given that views and definitions for sustainable development and responsible innovations can vary, it may be helpful to use qualitative approaches as assessment tools, mainly because they offer more versatility and can also be used to promote better practices.

Some scholars have been investigating the relevance of RRI for industry, which is clearly significant for future engineers. Developments in RRI that use qualitative assessments may be more appropriate for discovering concrete results and sustainability practices. For example, PRISMA is an RRI project that investigates company practices. The project used a bottom up approach to RRI investigations and recognizes that companies are already engaging in some responsible practices. For example, some companies have CSR practices in place and they also pay attention to conflicts between values. The PRISMA researchers have found, for example, that profit sometimes supersedes stakeholder interests and transparency (van de Poel et al. 2020, 699). They also suggest that companies can improve RRI practices through the following methods: “strategize for stakeholder engagement”, “broaden current assessments”, “place values at center stage”, “experiment for responsiveness”, “monitor RRI progress” and “aim for shared value” (van de Poel et al. 2020). The responsiveness element goes beyond merely discovering values to realizing outcomes. In this way, RRI goes beyond CSR assessments. By suggesting that companies experiment for responsiveness, they also draw attention to the technical creativity that is needed to discover potential solutions to social and environmental risks. This is also a key part of the exercise for the STS students.

2.2 Applied RRI for Engineering Students

The applied projects have created a new opportunity for educating STS engineers in responsible innovation theories and methods. In a group context, students identify a company or a lab and conduct research through interviews or ethnographic approaches. Students are asked to engage in an investigation of one field site (a lab or a company), reflect on a range of values in the innovation process and consider some of the trade-offs that are made by engineers and scientists in a real-world setting. Students examine the role of users and stakeholders, investigate relevant policy developments, identify potential risk issues and, if relevant, discover responsible solutions. The groups choose a variety of sites, including, for example, social media companies, energy companies, simulation research centres, medical

imaging projects, nanotechnology labs, cyber security companies, factories, alternative meat production and artificial intelligence applications.

Through the analysis, the students uncover various aspects of RRI that are important to their sites of analysis. These include collaborations with different stakeholders or academics from different disciplines, the inclusion of user experience in innovation, attention to privacy by design practices and the identification of possible solutions to social concerns. Students are able to assess key risks and benefits, which may generally arise in the specific research and innovation context where they are conducting their interviews. The initial desk research that students conduct enables the students to ask representatives from labs and companies pertinent questions about their innovation practices. Students often find that researchers have considered social and ethical values during the innovation process. In some cases, their research findings demonstrate that innovators respond to these risks with technical adjustments or they make changes to the practices or policies associated with the technical development. This can be surprising for some students, as this part of the innovation process is not typically highlighted in their engineering classes. If students find examples of technological adjustments that respond directly to social or environmental concerns, such as privacy-respecting mechanisms or sustainability measures, in their background research, then they are in a position to make suggestions for how the company or lab can address risk issues in the analysis section of their term project.

3 STS SUSTAINABILITY AWARDS

3.1 Method and General Outcomes

As a part of the 2021 and 2022 sustainability awards competitions, students were asked to use a responsible innovation approach and place an emphasis on sustainability. The students recruited companies and research sites, conducted their interviews, analyzed their interview transcripts and finalized their reports. The students reported on all of the values that they found through their research and highlighted values related to sustainability. Some students found that engineers considered sustainability solutions. Students also learned that innovators encountered value conflicts in their attempts to find sustainable solutions. The Faculty of Engineering administration supported the event through making and giving out certificates and listening to student presentations. Their participation helped to give the event prestige, which may have also helped to motivate the engineering students.

At the end of the Fall 2021 and Winter 2022 terms, the jury reviewed projects and considered them for the STS Sustainability awards. In the Fall semester, ten projects were sent to the jury from twelve STS sections (about 240 students) and they gave awards to five projects. In the Winter semester, the jury awarded three projects from six sections (about 120 students). The jury assessed the projects according to a focus on sustainability (40 marks), attention to key stakeholders (10 marks), the inclusion of relevant risk issues (10 marks), attention to solutions to risk issues and stakeholder concerns (10 marks), originality and creativity (20 marks) and writing (10 marks). The award categories varied in each semester, but included Outstanding STS Sustainability Award, Sustainability and Innovation Award, Social Justice and

Sustainability Award, Energy Futures and Sustainability Award and the Sustainability and Equity Award. Seven of the projects that received awards agreed to post their projects on the STS website after receiving permission from the companies that participated in their studies. I will provide some general examples of findings from their reports related to sustainability below (Science Technology and Society n.d).

Table 1. Sustainability Findings in Student Projects

Types of sustainability findings in student projects	Projects
Projects focused on sustainability technologies	• Cultured Meat: Meet the New Meat (Outstanding STS Sustainability Award 2021) • Sustainability Analysis of Turkey's Leading Geothermal Energy Company Based on Responsible Research and Innovation Theory (Energy Futures and Sustainability Award 2021**)** • Graphene-Based Solar Cells in the context of Responsible Research and Innovation (Outstanding STS Sustainability Award 2022)
Projects that found value conflicts related to sustainability	• Graphene-Based Solar Cells in the context of Responsible Research and Innovation (Outstanding STS Sustainability Award 2022)
Projects that discovered examples of the inclusion of sustainability adjustments to the technology	• Graphene-Based Solar Cells in the context of Responsible Research and Innovation (Outstanding STS Sustainability Award 2022) • Tangible Social Concerns in a Digitalized World: An RRI Case Study on Digital Transformation Technologies at TEKNOPAR **(**Sustainability and Equity Award 2022) • A Case Study on Karel Electronics Smart Home Technology Through the Lens of Responsible Innovation (Social Justice and Sustainability Award 2021)
Projects that identified sustainable practices	• AirCar: A "Jetsons" Dream Coming True (Sustainability and Innovation Award 2022)
Projects that included a vision for a future sustainable technology	• AirCar: A "Jetsons" Dream Coming True (Sustainability and Innovation Award 2022**)** • Responsible MRI: RMRI (Sustainability and Innovation Award 2021)

There were a few examples of companies that were working towards sustainable development goals, but award recipients also found examples of sustainability practices in other sectors (see Table 1; Science Technology and Society n.d.). For example, the geothermal project and the clean meat projects found that sustainability was a key goal for the companies that they consulted, so they were clearly building environmental values into their technology. The geothermal project noted that the company wanted to be the energy company of the future for Turkey and envisioned a future that would us mainly renewable sources. Students found that Biftek emphasized how conventional meat is not a sustainable option and a transition to

clean meat would help to solve this problem. While Graphene-Based Solar Cells is obviously focused on developing sustainable technology, students also discovered that researcher and engineers sometimes encountered conflicts between different types of values. For instance, through their interviews, students found that it is economically more viable to work with heavy metals, but they chose to use boron instead as it is a more sustainable option. The students pointed out that the innovators made this decision because they were concerned about environmental values. Other groups found that their interviews had made technical adjustments to improve sustainability. For example, TEKNOPAR used sensors that would keep track of electricity use and potentially reduce greenhouse gas emissions. Similarly, Karel had implemented smart plugs and lighting for the same purpose. The interviewees from the AirCar company indicated to students that their future technology would not actually be owned by individuals. Rather, they envisioned that future air cars would be shared by users, which is similar to sustainable car sharing practices that are already in place. Students also found that some of the sustainable technologies that were discussed by the innovators are still at the aspirational stage. However, although the AirCar technology is still in development, the engineers were already working towards significantly reducing emissions. Finally, the MRI group noted that the future development of smaller MRIs would make the technology more sustainable.

4 SUMMARY AND ACKNOWLEDGMENTS

4.1 Summary

The STS Sustainability Awards were an opportunity for engineering students to learn about sustainability issues, examine the unintended risks and identify possible solutions by using responsible research and innovation approaches. The students discovered industry-based sustainability practices through their efforts. It is possible that students may have a better understanding of the relevance of social and environmental values through conducting their investigations, but this would need further research. As noted above, engineering students do not always view courses that focus on social knowledge as relevant to their future technical careers. This learning activity addressed this problem in two ways. Firstly, by consulting innovators on the values that are included in the innovation process, students had an opportunity to realize that social values, including sustainability, are routinely considered by researchers and real-world developers. Secondly, perhaps by including participation from engineering faculty in STS course activities, it may have helped to validate the time that engineering students spent on the responsible innovation inquiries. However, these issues would need to be explored further by future researchers, as this paper only describes the project, the competitions and some of the key findings from student projects. Of course, there are ways that the project can be improved, if implemented again in the future. Although it is useful for students to find a company that is actively working on sustainable technologies, it is also important to discover the conflicts, risks or unanticipated consequences associated with the sustainable innovation that they are examining. This aspect does not always receive as much attention. Also, it is important to stay open to sustainable innovation practices in all sectors, rather than only investigating innovations that are exclusively focused on sustainability. Students were asked to imagine solutions for sustainability dilemmas, particularly if the innovators that they interviewed did not mention one, but this was not always successfully addressed. This dimension could

be developed much further, although students may not have always have time to identify appropriate solutions. Overall, the sustainability competition was a successful initiative, as it helped students to reflect on sustainability in innovation practices. The STS Sustainability Awards also provided a useful way to draw attention to STS student work on sustainability, as representatives from the Faculty of Engineering attended the events, presented certificates to award winners and heard the students give talks on their projects.

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