Understanding Faculty Decision-Making in Engineering Education for Sustainable Development

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Abstract

Engineering education for sustainable development (EESD) has emerged as a significant focus since the early 1990s, driven by the broader integration of sustainable development (SD) across education. SD has gained global attention and support from governments, businesses, and organizations. Still, education for sustainable development is emergent in engineering, and varies globally. Scandinavian countries, for example, have made significant progress in EESD with research and growth in courses and curricula, while the United States has seen more localized efforts. Prior research on EESD has focused heavily on course content and student learning, with far less attention to faculty attitudes and experiences.

To advance global integration efforts, this study provides a deeper understanding of faculty engagement with EESD. Drawing on Lattuca and Pollard's (2016) model of faculty decision-making to engage in curricular change, this study compares the perspectives of faculty at two universities, one in the U.S. and one in Denmark, to explore the influences that shape engineering faculty choices to engage in EESD. To operationalize EESD, the study focuses on faculty who incorporate the U.N.'s Sustainable Development Goals (SDGs) in their courses. Denmark and the U.S. were selected because of the wide divergence in national policies and practices relative to SD. The two institutions, however, are similar in engineering program size, research orientation (both very high research), and scope of engineering programs.

The research used a case study approach and included interviews with five to seven engineering faculty and two to three key informants at each site, along with available texts such as university mission statements, program descriptions, course syllabi provided by interviewees, and national policies or declarations. Lattuca and Pollard's model posits three levels of influence: external (outside the institution), internal (within the institution and the department), and individual (within the person) Findings suggest that all three categories of influence are present in each case, but the salience of each category, the specific factors within each category, and the interactions across categories differ markedly. Where the Denmark case had a more consistent alignment across the three levels of influence, with a largely top-down direction of influence, engagement in EESD in the US case was largely an individual, bottom-up phenomenon with some alignment to, but limited drivers from the external and internal levels.

This study captures the importance of strong external and internal influences in shaping faculty engagement in EESD and underscores the limitations of relying solely on individual influences. The findings highlight the role of national policies and cultural norms in creating a supportive environment for faculty to integrate sustainability into their teaching. Where external influences are limited, institutions need to actively align their vision, culture, and resources with the principles of sustainable development to foster a widespread and consistent practice of EESD. While individual faculty have been shown to act as change agents in the absence of strong external and internal influences, their efforts alone are limited in their impact on the practice of EESD.

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General Audience Abstract

Engineering education for sustainable development (EESD) has become an important focus in recent years as the concept of sustainable development (SD) has been increasingly integrated into education. Broadly, SD works to meet our current needs without harming future generations, and it has widespread global support from governments, businesses, and organizations. While the idea of teaching sustainable development is becoming more common in engineering programs, its implementation varies around the world. Scandinavian countries like Denmark have made significant progress in this area with research and the development of courses and curricula. In contrast, the United States has seen more localized efforts.

Most research on EESD has focused on what students learn in their courses, but with less work exploring why faculty members choose to include SD in engineering courses. To better understand why faculty members engage with EESD, this study looks at the perspectives of engineering professors at two universities: one in the U.S. and one in Denmark. In particular, it explores what influences faculty decisions to include the United Nation's Sustainable Development Goals (SDGs) in their courses. Denmark and the U.S. were chosen for this study because they have very different national policies and practices related to sustainable development. However, the universities in both countries are similar in size, focus on research, and the variety of engineering programs they offer.

Data for this study includes interviews with five to seven engineering faculty members and two to three key informants at each university. Documents like university mission statements, program descriptions, course outlines provided by interviewees, and national policies related to education were also collected. Though faculty at both universities talked about influences outside the university, influences within their institutions departments, and their individual beliefs and values, both the specific factors at each level and the interactions between factors varied. In Denmark, strong national and institutional policies, values, and norms in support of sustainable development broadly and EESD in particular were key sources of influence, while in the U.S., where sustainable development is more contested, individual faculty beliefs and commitments were more prominent, though these commitments often aligned with broader institutional values and some external drivers.

The study underscores the importance of both external factors, like national policies, and individual factors, such as personal beliefs, in shaping how faculty members integrate sustainable development in engineering. It highlights the role of government policies and cultural norms in creating an environment where faculty feel supported in integrating sustainability into their teaching. When external support is lacking, universities need to actively align their vision, culture, and resources with the principles of sustainable development to encourage consistent teaching of EESD. While individual faculty members can make a difference on their own, their impact is limited without strong external and internal support.

Dedication

I offer this work at Your lotus feet, Amma.
It represents my dedication and creativity,
a testament to the power of Your divine influence.
I am just an instrument.

निमित्तमात्रं
[Bhagavad Gita 11.33]

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1. Introduction

1.1. The Need for this Study

Sustainable development (SD) is a critical global imperative that strives to attain a state of peace and prosperity by addressing the needs of the people and planet (United Nations, 2015c). Defined first in the 1987 Brundtland Report as the "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs," (WCED, 1987, p. 41). SD has since been further described and refined by multiple frameworks, of which the most widely referenced currently is United Nations' Sustainable Development Goals (SDGs). The SDGs are 17 individual goals that collectively enable us to address challenges with concrete actions to achieve a sustainable world by 2030 (UNESCO, 2017). These goals were adopted by the 193 countries, including the United States, of the UN General Assembly and have received broad support from many NGOs.

While engineers are not solely responsible for achieving these goals, they do play a significant role in addressing the SDGs. For example, the U.S. National Society of Professional Engineers' Code of Ethics expects engineers "to adhere to the principles of sustainable development in order to protect the environment for future generations" (National Society of Professional Engineers, 2019, Sec. 3). In addition, the SDGs overlap with several of the 14 Grand Challenges for Engineering in the 21st century, such as providing access to clean water and ensuring access to clean energy (NAE, 2008). But the SDGs extend beyond to address food insecurity and gender equality (NAE, 2008; United Nations, 2015c). As a result, efforts to integrate education for sustainable development education are increasing within the field of engineering (Crofton, 2000; Guerra, 2017; McCormick et al., 2015), leading to substantial

research and initiatives aimed at revising engineering curricula to encompass sustainable development concerns.

In order to address the large-scale global challenges we are currently facing, scholars working in this space argue that engineering education needs to move beyond technical competence to holistically and systematically address SD (Crofton, 2000; Kohn Rådberg et al., 2020; McCormick et al., 2015; Pitt & Lubben, 2009). However, even though research on engineering education for sustainable development (EESD) showcases many instances of courses integrating the SDGs or similar ideas in various subject areas, the adoption of these approaches in engineering programs is not yet widespread. A survey of research studies on EESD published in the American Society of Engineering Education (ASEE), for example, indicated that efforts in EESD, particularly in the U.S., were predominantly localized to civil engineering, with the majority of studies focused on implementation at a classroom-level (Menon et al., 2022). Lucena and Schneider (2008) attribute this ad hoc approach to EESD in the U.S. to the individual educators who are motivated by their intent to provide students with educational opportunities relevant to society in the absence of larger systemic or programmatic initiatives. Moreover, trends in EESD vary nationally, with more research on EESD coming from some nations and regions than others. For instance, scholars in the Nordic countries, which generally score better on measures of the SDGs (Times Higher Education, 2021), have published extensively on EESD, indicating the importance given to integrating SD in engineering curricula (Holgaard et al., 2016; Shiel et al., 2005; Takala & Korhonen-Yrjänheikki, 2019). In contrast, according to study by Menon et al. (2022a), research on EESD represented a mere 5% of a publication database that predominantly focused on the US context. The current body of research thus suggests that while

EESD is occurring in various pockets around the world, it is not yet fully embedded across all engineering programs globally.

As noted above, much of current research focuses on approaches to curriculum design and student learning, and we have learned a great deal about what "works" (Barrella & Watson, 2016; Brennan & Riley, 2016; Conger et al., 2010; Guerra, 2017). However, far less research has addressed the faculty who are responsible for incorporating SD into their courses. Educating for the SDGs not only requires that faculty understand what SD looks like in engineering and how to embed these concepts in a core engineering subject, but also that they have an attitude and/or a mindset that values SD. It requires, for example, that educators are motivated to integrate SDGs in alignment with their disciplinary fields, with variations of problems and projects (McCormick et al., 2015; Nicolaou & Conlon, 2016). Given that course and curriculum design rests heavily on faculty decision-making, particularly in the absence of national or institutional mandates, achieving wider implementation of EESD globally requires a deeper understanding of engineering faculty members' perspectives of and decisions related to EESD.

1.2. The Purpose of this Study

To better understand the faculty choices in EESD, this exploratory comparative case study uses Lattuca and Pollard's model of faculty decision-making about curricular change (2016). Lattuca and Pollard define curricular change as a change in any aspect of a course or program development, including the purpose of education, content, sequence of courses or topics, instructional processes, instructional resources, assessment strategies, approaches to evaluation of courses or programs, and feedback loops of changes (Lattuca & Pollard, 2016). Notably, while Lattuca and Pollard focus specifically on the decision to engage in change, for this dissertation I adapted the model to look at more broadly at faculty engagement in EESD,

whether that engagement represents a change from previous practice or not. The model, which is elaborated in Section 3.2, identifies three categories of influences that affect faculty decisions regarding curricular choices: external, internal, and individual. External factors such as national policies, disciplinary and professional norms, and workforce needs, reflect larger cultural imperatives and can impact both internal and individual influences. Internal factors include the culture, vision, and resources of an institution as well as of its individual academic departments. Individual influences refer to the personal identities, experiences, knowledge, and beliefs of faculty members. This latter component of the model recognizes that while external and internal factors play a role in curricular change, individual faculty have the agency to act (or not to act) based on these influences. Because existing research suggest that EESD is both affected by national and institutional policies and dependent on the faculty's sustainability mindset, or a "frame of mind based on values and beliefs" towards sustainability (McCormick et al., 2015), this model offers a useful starting point for understanding engineering faculty decisions to incorporate the SDGs into courses. A comparative approach was then particularly useful for moving beyond the individual to examine the external and internal levels.

This exploratory comparative case study serves 1) to begin to understand the influences that support engineering faculty choices to integrate the SDGs in their courses, and 2) to investigate how these influences may differ across national and institutional contexts. First, using the Lattuca and Pollard model as a lens to understand the influences behind faculty decision-making in EESD enabled me to document the ways in which faculty are enabled to incorporate the SDGs in their engineering courses and curricula across multiple levels of influence. It allowed me to understand the sustainability mindset that is required to effectively integrate SD in engineering courses (McCormick et al., 2015), as well as the national and institutional cultures

that support and encourage faculty to engage in EESD. Second, by investigating differences across contexts, I was able to identify how the inclusion of SDGs in engineering education may be linked to national policies. Institutions in the Nordic countries, for example, have a systematic approach to the integration of SDGs in engineering education linked to national curricula policies (Holgaard et al., 2016; Shiel et al., 2005; Takala & Korhonen-Yrjänheikki, 2019) and as a result, the role of individual beliefs and perspectives is less clear. In contrast, EESD appears to be most often localized at the classroom level in the US (Menon et al., 2022) often driven by individuals (Lucena & Schneider, 2008). Given that EESD looks different depending on the national context and institutional or departmental culture, this comparative approach allowed me to understand the salient influences, and how they may differ across both sites, in the faculty decision-making process.

To achieve these goals, I used Lattuca and Pollard's model of faculty decision-making to explore the following research questions:

RQ1: What external, institutional, and individual influences support engineering faculty choices to integrate the SDGs in their courses?

RQ2: How do the influences vary within and across sites?

To address these research questions, I conducted a comparative analysis across two large public institutions, one in Denmark, and one in the United States, both with high activity levels of research. Drawing on the case study and comparative analysis methods described by Merriam (2007) and Miles et al., (2019), data included 5-7 faculty interviews at each site, along with key informant interviews across both sites, relevant national and institutional policies, and documents relevant to departmental and institutional culture.

A comparative qualitative case study aligns closely with the need and purpose of this study. Qualitative case studies are effective for education research as they allow an in-depth study of contemporary phenomena, such as faculty decisions to practice EESD (Case & Light, 2011; Merriam, 2007). In addition, a comparative case study allowed me to look at faculty decision-making on a global level and study the phenomena across national contexts. Furthermore, the case study approach supported the use of frameworks – in this case, the Lattuca and Pollard model – to guide the study design and the use of multiple rich qualitative data sources to develop each case (Merriam, 2007). Finally, rather than investigating barriers to EESD, I took an approach where I focused on the strengths and supporting influences of faculty decisions to engage in EESD across national and institutional contexts. While studies of barriers can be important, the removal of reported barriers does not guarantee implementation. As a result, I have instead chosen to focus on identifying factors that do support implementation. This work is, therefore, a first step towards understanding the factors that support faculty, which can then be developed in subsequent studies.

1.3. The Broader Impact and Intellectual Merit of this Study

This project, draws on research from various disciplines, including psychology on decision-making and policy perspectives on sustainable development, to understand faculty decision-making in EESD. This comparative study of two large research-intensive universities, one in the United States and one in Denmark, provides a global context to understand how national and institutional policies, as well as individual beliefs, impact local educational practices. Given the challenges associated with climate change, the increasing frequency and intensity of natural disasters, and growing social and economic disparities, it is essential that engineering educational programs embed sustainable development holistically into students'

development. While several researchers have demonstrated effective educational approaches, comparatively few faculty, particularly in the United States embrace EESD. By examining the faculty who are incorporating sustainable development in their courses, I took an approach that looks at the existing strengths of why faculty engage in EESD, and thus, was able to identify the salient factors behind these efforts, that can then be emulated. Key findings from the study showed that the faculty decisions to engage in EESD were heavily supported by the external and internal influences at the Denmark case, whereas the individual influences in the US case strongly shaped faculty decisions in spite of weak external and institutional influences. Thus, this study serves as a key step in advancing EESD nationally.

1.4. Strengths and Limitations

While this exploratory study is a valuable first step to understand faculty decision-making in EESD and work towards a wider and systematic implementation of EESD globally, it is bounded and limited in several ways. First, this study develops two cases that were specifically bounded by institution type and national context. It is, therefore, not generalizable to other settings, though the institutions themselves may be considered representative of particular institution types and thus may contribute to transferable knowledge. Next, this comparative study has to two cases, due to constraints in time and resources. Merriam (2007) suggests six or more cases in a multi-case design as it enhances the generalizability or external validity. The two selected cases thus offer an initial exploration that can be further developed in subsequent research. Additionally, because recruitment methods include snowball sampling participants, I have only been able to access a subset of engineering faculty who engage in EESD at both institutions; to mitigate this limitation, I supplemented the faculty interviews with national and institutional documents as well as interviews with key informants at each site.

In spite of these limitations, the study has several strengths including the focus on supports, the richness of qualitative data, and the comparative analysis of the phenomenon across national contexts and institutional culture. First, choosing to study faculty decisions to incorporate SD in their engineering courses allowed me to understand the factors that enable and support EESD. Next, conducting qualitative interviews allowed me to investigate the phenomena in depth and present detailed explanations in a way that a large-scale quantitative study would be unable to capture. Finally, selecting two institutions from two different national contexts allows me to trace across both sites to look for the influences that support faculty choices to engage in EESD. Thus, this study is useful for a deeper understanding of engineering faculty members' perspectives of, and decisions related to EESD.

1.5. Overview of Chapters

This chapter covered the need purpose, broader impact, and limitations of the study. I review the literature on engineering education for sustainable development and faculty decision-making in Chapter 2. Chapter 3 outlines the design of the comparative case study, including the case definition, site selection, data sources and analysis methods. In Chapter 4, I present the findings, including the salient influences that emerged from each case and from the cross-case analysis. Chapter 5 places the findings within the framework of existing literature. Lastly, Chapter 6 delves into the conclusions and the implications from this study.

2. Literature Review

Engineering has played an important role in addressing some of humanity's greatest social and technological challenges and continues to do so in working toward sustainable development (SD). But while engineers have contributed to meeting various societal needs including health care, communication, and transportation, many economies around the globe are also becoming "unsustainable because of engineering" (Ashford, 2004, p. 1). Engineering has created wide-ranging inventions that all rely on increasingly sophisticated ways of accessing and using fossil fuels. But those same inventions are significant factors in global climate change and the devastation experienced, for example, by coastal communities as sea levels rise (Karl, 2009). To better address the potential value and mitigate the potential damage of engineering work, engineering education is a critical opportunity for all engineering students to reflect on the existing challenges of SD, the implications of their design choices, and their responsibility to society as engineers of tomorrow (Ashford, 2004; Lucena & Schneider, 2008). As a result, research in engineering education has been investigating methods to successfully integrate sustainable development.

Currently, however, SD is not universally integrated into engineering programs, with wide variations globally and limited integration across the United States in particular. The variation in EESD can be seen on many levels. On a global level, some countries prioritize the integration of SD in engineering education in a way that integration can be seen in curriculum design. For example, Finnish universities embed SD in engineering education more intentionally (Takala & Korhonen-Yrjänheikki, 2013, 2019), whereas in the U.S., the presence of SD is more often dependent on departments or even individual faculty, with more work evident in disciplines like civil and environmental engineering (Menon et al., 2022). In addition, several studies in

EESD research indicate that most of the integration of SD is ad-hoc, often initiated by an individual faculty member, and can vary depending on faculty interpretations and perspectives of SD (Allenby et al., 2009; Rampasso et al., 2019; Salvatore et al., 2016). Given that in the U.S. and many other countries, the incorporation of SD into engineering courses is faculty dependent, it can be useful to understand why faculty do such integrative work. While many studies approach faculty adoption of emergent pedagogies from a deficit perspective, looking at barriers (Huang et al., 2007; Lee et al., 1997; Sturtevant & Wheeler, 2019), I chose to approach it from a more positive perspective to better understand faculty who do this work. To situate my work, this chapter first lays out an understanding of SD, then considers what we know about teaching SD in engineering, and finally, turns to research on faculty decision-making.

2.1. Defining Sustainable Development

The connection between SD and engineering (and thus engineering education) is not often explicitly expressed. The term 'sustainable development' itself can be ambiguous and broad, making it difficult to connect it with engineering. To understand the context of this project and the concept of engineering education for sustainable development, I begin with accepted definitions and frameworks that describe SD, explain how I operationalize SD for the context of this study, and illustrate how this operational definition is reflected in engineering and education. I also present a brief history of how SD emerged as a priority in education, the engineering profession, and engineering education.

2.1.1. The Brundtland Commission

While concerns about the environment and global development existed since at least the early 1970s, it was not until the Brundtland Commission in 1987 that the term "sustainable development" was formally defined. The Brundtland Commission, also known as the World

Commission on Environment and Development, was established by the United Nations to address issues related to the environment and economic development. The commission's report, entitled "Our Common Future," defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 41). The report presents seven imperatives, which cover what are now referred to as the economic, social, and environmental dimensions of SD (Gagnon et al., 2009; WCED, 1987). Since the Brundtland Commission's report, the concept of SD has gained widespread attention and has been embraced by governments, businesses, and other organizations around the world (Jeronen, 2013; Ruggerio, 2021).

The Commission's definition, however, was criticized for its ambiguity and contradictory ideas. For example, the term "development" is associated with economic growth, which to some is "incompatible" on a "finite planet" (Ruggerio, 2021, p. 3). As a result, several theoretical perspectives and frameworks have been identified to better interpret the Brundtland definition of SD. Extensive reviews of these perspectives and frameworks, though outside the scope of this dissertation, have been provided by Gagnon et al., (2009), Jeronen (2013), and Ruggerio (2021). While the various frameworks reflect the different disciplinary perspectives and concerns, the broad Brundtland definition of SD remains widely cited, and continues to underpin broader global conversation.

In framing this dissertation, it is also important to note that SD is often used interchangeably with the term "sustainability," especially in academic and scientific fields (Olawumi & Chan, 2018; Ruggerio, 2021) While these terms may be used interchangeably in some contexts, in practice sustainability is often used to refer more narrowly to ecological issues only, and some schools of thought argue that SD is different from sustainability (Jeronen, 2013;

Ruggerio, 2021). For the purpose of this study, however, I recognize that "sustainable development" and "sustainability" are often used interchangeably in the academic setting broadly and in engineering education in particular, and thus my review of the literature included searches using both terms. In my own work, though, I explicitly use the term "sustainable development" to capture a more expansive understanding and position my work within the broader research on education for sustainable development. I also choose to use the UN Sustainable Development Goals to operationalize SD, which I elaborate on in the next section.

2.1.2. The UN SDGs

Given the diversity of terms and frameworks, for the purposes of scoping this dissertation, I have chosen to operationalize sustainable development by using the United Nations Sustainable Development Goals because of their broad global relevance and current use in both engineering and educational contexts. In 2015, the 17 UN Sustainable Development Goals (SDGs), shown in Figure 2-1, were adopted by the 193 countries of the UN General Assembly as a way "to cultivate and expand humanity's desire to do good while also organizing its ability to do so" (Zelinka & Amadei, 2017, p. 3). These SDGs address today's challenges with concrete actions to achieve a sustainable world by 2030 (UNESCO, 2017). The SDGs define the five "Ps" of the mission of the SDGs: people, planet, prosperity, peace, and partnership (Sachs, 2012). To accomplish the mission, the goals argue for a "balance [between] the three dimensions of sustainable development: the environmental, social and economic (United Nations, 2015c para. 1). These goals recognize that to eliminate poverty and address various limitations and shortcomings in society, it is essential to implement approaches that enhance healthcare standards, expand educational opportunities, decrease disparities, promote economic advancement while tackling climate change and preserving oceans and forests, are necessary.

Figure 2-1 The UN Sustainable Development Goals (United Nations, 2015b)
Icons used for informational purposes only.

The UN SDGs framework has been useful for higher education institutions (HEI) as well as the engineering profession to share a "common language" in defining educational, research, and professional objectives (Seneviratne, 2022). For example, the SDGs serve as a framework at several universities worldwide to educate socially responsible graduates (Seneviratne, 2022). The SDGs enable students to think about the development needs not just in a local context, but in national and global contexts as well. Azeiteiro et al., (2019) describe the role of SDGs in higher education and the research that the framework has helped advance in various parts of the world including Europe, Asia, Latin America, and Africa. In addition, The UNESCO Engineering Initiative (UEI) and its partners are working to design engineering curricula that incorporate sustainable development as an encompassing theme (UNESCO, 2016). Their goal is that graduates of all engineering fields will be expected to have a deep knowledge and thorough understanding of sustainable development fostered throughout their university education. Given that the SDGs are globally recognized, especially in HEI and engineering, they are a useful framework to operationalize SD, particularly for cross-national comparisons.

2.1.3. Sustainable Development in Engineering

The movement towards sustainable development was apparent in the professional engineering practice soon after the Brundtland Report. In 1990, the International Federation of Consulting Engineers (FIDIC) introduced guidelines for consulting engineers for their projects and clients, which included the following: “Engineers should provide leadership in achieving sustainable development” (Byrne et al., 2010, p. 7). In 1992, after the Rio Summit, the World Federation of Engineering Organizations (WFEO) formed a collaboration with the FIDIC and the International Union of Technical Associations (UATI) to lay the groundwork for the many programs that support SD, referred to as the World Engineering Partnership for Sustainable Development (Byrne et al., 2010; W. J. Carroll, 1993). Engineers Australia added a policy that required “members [..] to act in a manner that on sustainability achievement of sustainability” (Byrne et al., 2010, p. 7; Carew & Mitchell, 2008). The chemical engineering profession globally pledged to work towards SD. In 1997, 18 organizations that represent the chemical engineering professionals around the world signed the London Communiqué, which pledged “to make the world a better place for future generations” (Byrne et al., 2010), and in 2001, twenty chemical engineering institutions signed the Melbourne Communiqué committing to work towards SD (Byrne et al., 2010). In 2004, the United States National Academy of Engineering (NAE) formulated its vision of the Engineer of 2020 which called for “for engineers to be informed leaders in sustainable development” (Byrne et al., 2010; NAE, 2004). This was followed by the twelve “Guiding Principles for SD” published by the Royal Academy of Engineering in 2005 (Byrne et al., 2010). These principles, as listed below, were identified based on the engineering aspects of, or the role of engineering in SD:

1. Look beyond your own locality and the immediate future

2. Innovate and be creative

3. Seek a balanced solution

4. Seek engagement from all stakeholders

5. Make sure you know the needs and wants

6. Plan and manage effectively

7. Give sustainability the benefit of any doubt

8. If polluters must pollute… then they must pay as well

9. Adopt a holistic, 'cradle-to-grave' approach

10. Do things right, having decided on the right thing to do

11. Beware cost reductions that masquerade as value engineering

12. Practice what you preach. (RAE, 2005, p. 25)

2.2. Sustainable Development in Education

The commitment to SD in the engineering profession is linked to SD in engineering education. Addressing the social, economic, and environmental aspects of SD in engineering courses and curricula goes far beyond textbook knowledge or the traditional experiences of engineers' formal training, and the research on EESD has studied this integration of SD into engineering education from several perspectives. One area of research looks at student learning and attitudes, such as their holistic development of acquiring technical knowledge and competencies while building a mindset and professional identity aligned with sustainability. Another area addresses course pedagogies and curriculum design, where effective practices of incorporating SD in engineering education are studied. A third area looks at the perspectives of faculty and university leadership. Following a brief history of education for SD, each of these research areas is described in detail in the following sections. Of the three areas of EESD

research, far less has looked at the faculty perspectives on EESD, thus creating the need for this dissertation.

2.2.1. The Emergence of Education for Sustainable Development

Working towards SD has resulted in specific efforts towards education for sustainable development (ESD) globally. In 1992, the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro resulted in the adoption of Agenda 21, detailed plan for actions to be taken worldwide, nationally, and locally in all the ways people affect the environment. This agenda was one of the first initiatives to acknowledge the importance of education to promote sustainable development (Hopkins, 2022; Tilbury, 1995). While there existed disciplines such as environmental education (Tilbury, 1995) and development education (O'Flaherty & Liddy, 2018) that focused on environmental and global development topics in education, respectively, Chapter 36 of Agenda 21 developed a framework to strengthen and reorient existing education towards sustainable development as a coherent, integrated concept across fields (Hopkins, 2022; UNCED, 1992). In the same vein, the UN designated the years 2005 to 2014 as the UN Decade of Education for Sustainable Development (DESD). According to the United Nations, ESD is education that encourages changes in behavior that will create a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations (UNESCO, 2016).

2.2.2. Education for Sustainable Development in Engineering

In the same way that professional engineering organizations started prioritizing SD in core engineering principles, this shift was reflected in engineering education. In 2006, the International Federation of Engineering Education Societies (IFEES) was formed to promote "effective engineering education processes of high quality around the world" (Morell et al.,

2008, p. 7) According to the IFEES, in order to ensure "a global supply of well-prepared engineering graduates," one of the key points that engineering education needs to address is the following question: "How can education in science and technology help to reduce poverty, boost socio-economic development, and take the right decisions for sustainable and environmental compatible development?" (Morell et al., 2008, p. 5). IFEES marks one of the first initiatives in engineering education for sustainable development, though that initiative was preceded and informed by the earlier milestones. Figure 2-2 illustrates these milestones over time, from when the formal definition of SD in 1987 was established to the early indications of SD entering education and engineering education in the early 2000s.

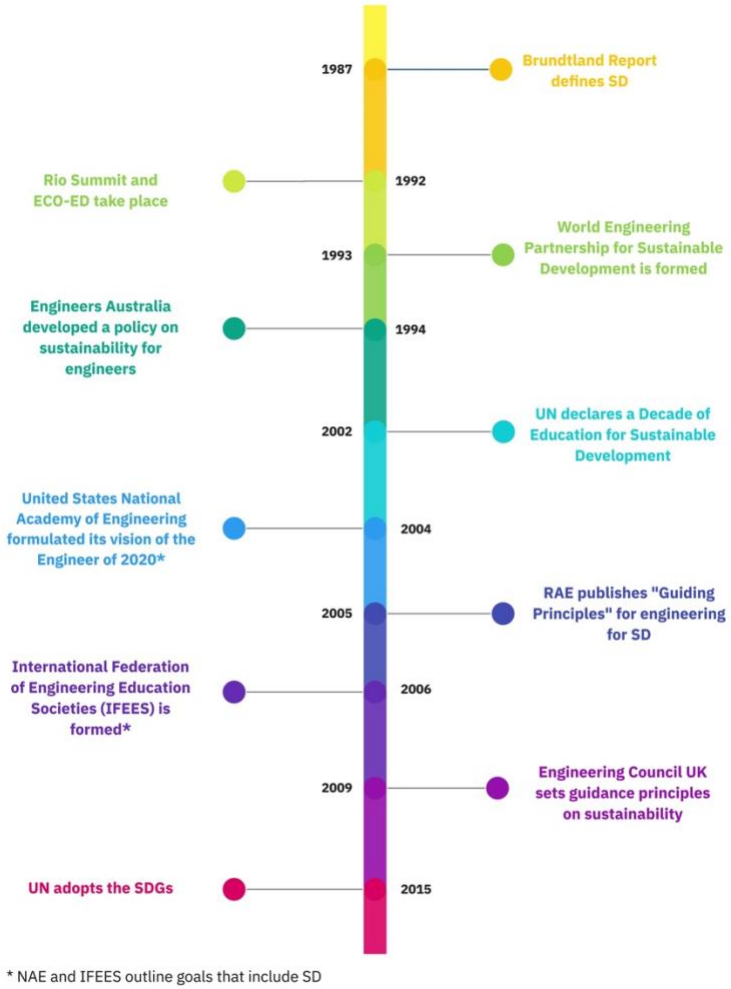

Figure 2-2 Emergence of SD in education and engineering

Within engineering, explicit disciplines that align with SD have emerged in engineering colleges, most notably "sustainable engineering," and "humanitarian engineering." Like the term 'sustainability' discussed earlier, sustainable engineering typically maintains a clear environmental focus. Sustainable engineering involves adopting methods that support the well-being of the environment, society, and economy by using resources more efficiently, decreasing pollution, and taking into account the broader societal effects of new technologies, procedures, and approaches (Brennan & Riley, 2016; UNESCO, 2017). Sustainable engineering highlights natural resource preservations, and eco-efficient solutions that support natural environments. Humanitarian engineering refers to an explicit sociotechnical approach in engineering "to enhance the social, environmental, and economic sustainability" (*Humanitarian Engineering*, n.d. para 1; Mazzurco & Daniel, 2020). While such disciplines are available for engineering students to pursue, the rise of these programs also indicates a lack of integration of SD in other engineering disciplines (Lucena & Schneider, 2008).

At the same time, the impetus for engineering education to address the challenges of SD is undeniable. With the growth of journals such as *Environment, Development and Sustainability* (2002-present), *Engineering Sustainability* (2003-present), and the *Journal of Engineering for Sustainable Developmen*t (2006-present) as well as NGO-driven organizations such as Engineers for a Sustainable World (ESW) and student organizations, such as Engineers in Technical, Humanitarian Opportunities of Service Learning (ETHOS), engineering education appears motivated to develop global competencies and contribute to SD endeavors (Lucena & Schneider, 2008). Thus, there has been an increased awareness of "the need for engineering education to incorporate sustainability knowledge and skills" (Byrne et al., 2010, p. 2). While there is no formal definition for the widely used term "engineering education for sustainable development"

(EESD), Byrne et al. (2010) describe it as an "all-encompassing term, including the teaching of technical, social and economic aspects of development" (p. 3), and research related to EESD has been steadily growing Section 2.2 provides a detailed discussion of current research and trends in EESD.

2.2.3. Student Learning and Attitudes

One key area of EESD research has focused on competencies needed for EESD, including broad-based competencies such as communication and collaboration skills, holistic understanding, critical and analytical thinking, creativity, systemic thinking, and an ability to work in transdisciplinary frameworks (Byrne & Mullally, 2016; Lönngren & Svanström, 2016; Quelhas et al., 2019). In addition, studies have pointed to competencies such as the ability to identify and consider the broader social, economic, environmental, ethical, and political issues, and to recognize the local and global context of a problem needs to be incorporated into problem-solving skills (Crofton, 2000; Hariharan & Ayyagari, 2016; Mihelcic et al., 2006). However, scholars also suggest that effective integration of sustainable development in engineering education requires more than individual competencies and should teach sustainable development as a "sustainability mindset," or a "frame of mind – incorporating and making explicit the values and behavior that govern sustainable decision-making" (McCormick et al., 2015; Michelfelder & Jones, 2016; Pitt & Lubben, 2009; Pujol & Tomás, 2020). When graduating, engineering students should have not only the necessary competencies but also the values consistent with the sustainability paradigm.

2.2.4. Pedagogies and Curriculum Design

Engineering education research has been exploring ways to support these competencies and incorporate SD effectively into courses and curricula. Much of the current research on EESD

focuses on implementation, typically at one of two levels: curriculum-level design and course-level pedagogies. At the curriculum level, two common methods for the incorporation of sustainable development include vertical and horizontal integration. Vertical integration is the approach in which individual sustainability-focused courses are added to a program (Barrella & Watson, 2016). In contrast, horizontal integration is where sustainable development is embedded across the curriculum into a variety of classes (Barrella & Watson, 2016). Vertical integration is more common because of the ease of adding new sustainable development courses into an existing curriculum (Brennan & Riley, 2016; Nicolaou & Conlon, 2016). In this context, at the course level, problem-based learning (Guerra, 2017; Pujol & Tomás, 2020; Struck Jannini et al., 2016) and experiential learning (Conger et al., 2010; Murcott, 2016; Winkelman et al., 2016) have been reported to be effective approaches to develop the required competencies along with the sustainability mindset in engineering courses.

2.2.5. Faculty Perspectives of EESD

While current work around EESD has looked at student perspectives and pedagogical approaches, little research has examined how and why faculty are driven to teach for SD in their engineering courses. Generally, research on faculty development and faculty practices tells us that instructors resist or choose not to adopt new pedagogies because of gaps in knowledge, time restrictions and uncertainty about success (Finelli et al., 2013, 2014; Graham, 2012; Matusovich et al., 2014). Within EESD in particular, the limited research that is available has shown that gaps in knowledge are a key problem. For example, the common misconception that sustainable development relates primarily to environmental issues is held by program chairs, faculty, and students across a range of countries (Björnberg et al., 2020; Mitra et al., 2016; Nicolaou & Conlon, 2016; Rampasso et al., 2019; Salvatore et al., 2016). Upon surveying several program

chairs in three Irish Higher Education Institutions about their views of sustainable development and the integration of it in their curriculum, for example, Nicolaou & Conlon (2016) found that because of their narrow understanding of sustainable development, their approach to engineering education neglected all the aspects of SD and focused instead on the technical engineering competencies. Similarly, studies to identify faculty perceptions of embedding SD into engineering education in Finland, Ireland, and Brazil (Rampasso et al., 2019; Salvatore et al., 2016; Takala & Korhonen-Yrjänheikki, 2019) indicate that while a great deal of interest exists among faculty, the practice of EESD focuses largely on environmental issues, such as climate change and energy. This research shows that understanding faculty interests or beliefs alone is not enough to identify the key to successful educational reform.

More broadly, across engineering education, researchers have shown that sustainable and successful curricular change around any issue requires "department-level buy-in and effort" (Graham, 2012; Lattuca & Pollard, 2016). Faculty need to be provided the required training and support in order to sustain their commitment to curricular innovations (Graham, 2012; Lattuca & Pollard, 2016). Otherwise, these efforts are limited to small-scale impacts that are restricted to isolated classroom-level changes, as reflected in current EESD efforts in the U.S.

2.2.6. Global EESD

While research on pedagogies for EESD shows similar findings across countries, implementation levels differ widely. Such differences are perhaps not surprising given that globally, sustainable development looks different in terms of a country's performance of SDGs and national policies. For example, a study shows that the perspectives of sustainable development vary by country within Southeastern Europe (Ivanovic et al., 2009). These perspectives are influenced by the political and economic conditions in the country (Ivanovic et

al., 2009). The study revealed that while countries "at a medium level of development," such as Hungary and Romania, gave more importance to the economic aspects of SD, the developed countries, such as Germany and France, painted a more even picture of SD, valuing the ecological and social aspects of SD as well as the economic dimension (Ivanovic et al., 2009). These differences can be reflected in the research and initiatives to integrate sustainable development into the engineering curriculum.

While the United States is working towards SD, ranking 32nd in the world, according to the Sustainable Development Report released in 2021 (*Sustainable Development Report 2021*, 2021), it is "far behind most other high-income countries" (Neve, 2021 para. 3). The United States is doing well with certain goals such as SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth), but threats to biodiversity, and high levels of pollution and CO_2 emissions bring down the country's SGD Index (Lafortune, 2019). This limited engagement correlates with the ad hoc approach American universities have in integrating SD into the engineering curriculum. Lucena and Scheinder (2008) point out that US engineering education has been slow in incorporating SD in the curricula, through factors contributing to a push towards EESD include industrial and political practices context, accreditation criteria, faculty interests, and the growing interest in engineering ethics (Lucena & Schneider, 2008; Manion, 2002). According to a study I conducted, research studies on EESD published in the American Society of Engineering Education (ASEE) are predominantly localized to a single engineering discipline - civil engineering - with the majority of the studies, focused on implementation at a classroom level (Menon et al., 2022). In addition, certain universities in the U.S., such as Rowan University and Arizona State University, seemed to have published more classroom-level case studies on EESD (Menon et al., 2022). The study also revealed that only 1590 papers out of the

total 35485 publications, less than 5% of the ASEE PEER online database discussed EESD (Menon et al., 2022).

The Scandinavian countries, in contrast, are leading in their performance of the SDGs, with an SDG Index above 80 (out of a possible 100) (Acciona, 2019; UNSDSN, 2021). This national performance is also reflected in education initiatives where universities such as KTH and Mälardalen University in Sweden and Alborg University in Denmark prioritize sustainable development in both curricula and research (Gröndahl & Franzen, 2016; Guerra, 2017; *Mälardalens Högskola*, 2021). A review of Finnish engineering education for sustainable development indicated that the universities are committed to SD and integrate SD in all the degree programs (Takala & Korhonen-Yrjänheikki, 2019). In addition, a review of research studies published at the EESD conference showed that authors from Sweden, the Netherlands and Catalonia contributed the largest number of articles (Coral et al., 2018).

Denmark exemplifies taking actionable steps towards SD as a nation, and this priority is reflected in its educational and research practices. In 2021, Denmark was ranked second in its SD efforts (Mulhern, 2021). As a society that relied on agriculture and fishing, Denmark's respect for nature has contributed to the value given to SD. In 2009, the Danish Ministry of Education made a plan to include sustainable development in school subjects like science and humanities through various levels of education, which supported teacher training in primary education (Department of Higher Education and International Cooperation, 2009; The International Alliance of Leading Education Institutes, 2009). While this report does not explicitly define strategies or policies for higher education, it does mention the need to establish "research-based knowledge […] to strengthen education for sustainable development" and to develop "multidisciplinary higher education programs […] that relate to sustainable

development" (Department of Higher Education and International Cooperation, 2009, p. 23). In addition, Danish engineering institutions have included sustainability in their institutional priorities (Holgaard et al., 2016). These priorities can be seen in their research initiatives, student associations, and university-industry relations. Even so, Danish universities have experienced challenges in advancing EESD. Findings from a national survey of Danish engineering students indicated that the students entering the engineering program with a math/science focus have a lower intrinsic motivation for SD (Haase, 2014). In spite of the strong ESD initiatives in Denmark, the study shows that not all students welcome the emphasis on SD in their engineering curriculum. In addition, there is no systematic or national training specifically for ESD that is available to educators in Danish higher education institutions (Holgaard et al., 2016). It is important to recognize, that while Denmark is excelling in ESD and EESD initiatives, the Danish engineering education faces challenges similar to those from other countries.

2.3. Faculty Decision-Making

Given that faculty participation is integral for the integration of SD into engineering curriculum, it is important to understand faculty decisions that support EESD, and this project seeks to address that need. Faculty decision-making has been studied predominantly to understand teaching practices and curricular choices. These decisions, broadly defined as those "made during the execution of the professional responsibilities of the teacher" (Sutcliffe & Whitfield, 1979, p. 16) include those involved in pre-active teaching and interactive teaching (Yellin et al., 2007). Pre-active teaching decisions refer to those that faculty make while planning a course, while interactive teaching decisions refer to those made spontaneously while teaching a class (Huang et al., 2007; Yellin et al., 2007). Pre-active decisions, such as planning a course and program offering, and the decision to engage in curricular and instructional change are often

influenced by external influences such as the socio-political context of higher education, workforce needs, and efforts to quantify educational value and return on investment (Carroll et al., 2014; Lattuca & Pollard, 2016; Lattuca & Stark, 2009). For instance, the decision to switch to an online or hybrid learning platform during the COVID-19 pandemic was influenced by external factors, such as national regulations. Needless to say, the study of decision-making in itself is difficult because of the "invisible decisions" that cannot be observed or are not reported, and the ephemeral nature of the decision-making makes it difficult to capture (Huang et al., 2007). This challenge is reflected in the paucity of studies in faculty thinking, conceptions, and decision-making (Huang et al., 2007; Lattuca & Pollard, 2016).

2.3.1. Lattuca and Pollard's Model of Faculty Decision-Making

To support my exploration of faculty decision-making regarding EESD, I have chosen to adopt Lattuca and Pollard's (2016) model of faculty decision-making about curricular change. Lattuca and Pollard define curricular change as a change in any aspect of the course or program development, including the purpose of education, content, sequence of courses or topics, instructional processes, instructional resources, assessment strategies, approaches to evaluation of courses or programs, and the feedback loop of changes (Lattuca & Pollard, 2016; Menon, Paretti, et al., 2023; Menon & Paretti, 2023). The model, as shown in Figure 2-3, identifies three contextual influences that play a role in faculty decisions regarding curricular choices: external, internal, and individual. External factors, such as national policies, disciplinary or professional norms, and workforce demands, can directly affect both internal and individual influences. Internal factors refer to aspects within the institution such as the institution's mission and culture; it also includes culture and policies on a departmental level. Individual influences refer to the identity, experience, knowledge, and beliefs of faculty members. This component of the model

recognizes that while these factors play a role in curricular change, individual faculty have the agency to act (or not to act) based on these influences.

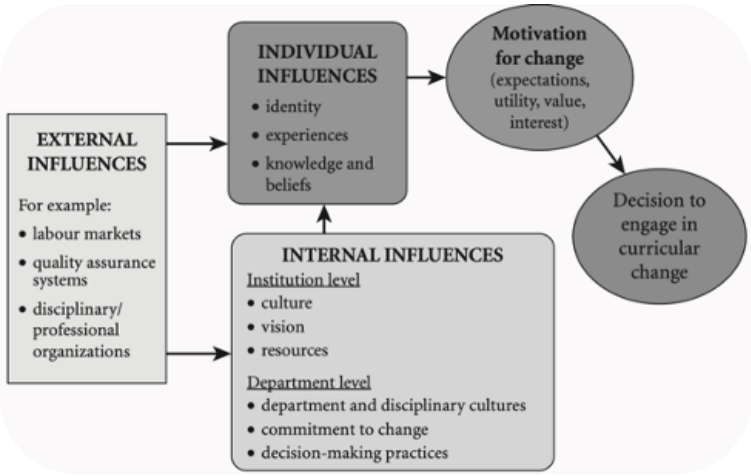

Figure 2-3 The Lattuca and Pollard model of faculty decision-making.
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2.3.2. Influences on Faculty Decisions

Lattuca and Pollard's influences reflect a wide range of prior studies on faculty decisions and practices. For example, at the individual level, researchers have identified teaching goals, motivation, and competence beliefs, all of which can be categorized as individual influences, as factors in faculty willingness to engage in research-to-practice cycles (Dingwall et al., 2011; Lattuca & Pollard, 2016; Matusovich et al., 2014) Other studies indicate that demographic characteristics of faculty members, such as gender and sexuality, can affect goals and beliefs about teaching (Katz & Knight, 2017; Link et al., 2008; O'Meara & Campbell, 2011; Patridge et al., 2014). In a survey by Katz and Knight (2017), for instance, female faculty placed a higher emphasis on believing that ethics should be addressed in the engineering curriculum. In addition, the academic discipline of a faculty member, or their disciplinary identity, is one of the strongest influences on professional attitudes, including the likeliness to engage in curricular change (Katz

& Knight, 2017; Lattuca & Pollard, 2016; Warcholak, 2014). Other individual influences behind course planning decisions include prior educational and/or work experience, as well as beliefs about student learning and cognition (Emil & Cress, 2014; Hatikvah & Goodyear, 2002; Stark, 2000; Sutcliffe & Whitfield, 1979). In addition, personal values such as family commitments can also influence teaching decisions (Huang et al., 2007; Sattler et al., 2007; Yellin et al., 2007).

Other research studies have identified various internal and external influences that shape faculty decisions. Internal influences, such as the departmental environment and reward structures within the institution, have influenced the distribution of how faculty members allocate their time to teaching, research, and service (Blackburn et al., 1991; Fairweather, 2002; Huang et al., 2007; Lattuca et al., 2010). Barker et al. (2015), for example, found that computer science faculty adopted new teaching practices based on conversations with their colleagues, while Ford-Baxter et al. (2022) examined how faculty use national standards to design their curricula, and found that faculty were generally more aware of local (state) requirements and program learning outcomes rather than national ones. While a full review of this literature is outside the scope of this dissertation, Table 2-1 synthesizes prior literature on faculty decisions and provides some of the influences that affect faculty curricular decisions, organized by the three contextual influences defined in the Lattuca and Pollard model.

Influences			**Related Works**
Individual influences	experiences, beliefs, and knowledge	beliefs about teaching and learning	(Barker et al., 2015; Brown & Knight, 2014; Emil & Cress, 2014; Hativa & Goodyear, 2002; Martin et al., 2000; McKenna et al., 2014; Stark, 2000)
		prior and current work experiences/roles	(Brown & Knight, 2014; Katz & Knight, 2017; Magnell et al., 2014)
	motivation	teaching goals and motivation	(Lattuca & Stark, 2009; Matusovich et al., 2014; Stark, 2000)

Influences			Related Works
	identity	gender and sexuality	(Katz & Knight, 2017; Link et al., 2008; O'Meara & Campbell, 2011; Patridge et al., 2014)
		departmental/ disciplinary affiliation	(Bielefeldt, 2015; Katz & Knight, 2017; Lattuca & Stark, 2009; Lindblom-Ylänne et al., 2006; Stark et al., 1997)
Internal influences	institutional	institutional policies and culture	(Blackburn et al., 1991; Fairweather, 2002; Harper & Lattuca, 2010)
		time allocation/reward structures	(Austin & Gamson, 1983; Barker et al., 2015; Blackburn et al., 1991; Huang et al., 2007; Lee et al., 1997; Link et al., 2008)
	departmental	peer support	(Barker et al., 2015; Fairweather, 2002)
External influences	accreditation standards	national disciplinary standards and local program outcomes	(Ford-Baxter et al., 2022; Gamage et al., 2020; Lattuca et al., 2010; Lattuca & Pollard, 2016; Stark, 2000)

Table 2-1 Influences behind faculty decisions

Although Lattuca and Pollard developed the model specifically to explore faculty engagement in curricular change, I have adapted it more broadly for this study to examine faculty engagement in EESD whether or not the engagement represents a change from previous practice. The complexity of SD and its connections to global and national policies and practices, as elaborated in this chapter, along with the research highlighted in Table 2-1, suggests that the levels identified by Lattuca and Pollard are likely to be relevant to faculty decisions surrounding EESD. Moreover, given that the desired impact of this project is to identify the influences that support and enable faculty to engage in EESD as a first step towards a systematic curricular change in U.S. engineering education, the model is well suited to the larger goals of my research. Notably, although the model links these categories of influence to motivation for change, or "situational motivation" (Lattuca & Pollard, 2016), which is grounded largely in expectancy-value theory), in this study, I am not exploring motivation constructs as outcomes. Instead, I limit the use of the model to study the individual, internal and external influences. Thus, I am not

applying the model to study the decision to engage in curricular change, but to identify the influences behind the faculty decision to engage in EESD.

2.4. Summary

As engineering education strives towards preparing future engineers to work responsibly towards SD, the literature indicates that SD is yet to be universally and systematically integrated into the engineering curriculum. Due to various external factors, such as national priorities and the socio-political climate, there is variation in what EESD looks like around the world. While Nordic countries have demonstrated a more consistent effort to integrate SD in education, in the U.S., such initiatives are largely faculty dependent. However, the majority of EESD research has studied student learning and effective pedagogies, with little research on understanding faculty perspectives of integrating SD in engineering courses. Using the widely accepted UN SDGs as a framework to operationalize SD, and the Lattuca and Pollard model of faculty decision-making to understand the individual, internal and external influences, this comparative study between the U.S. and Denmark addresses this research gap.

3. Research Methods

This study serves to explore the external, institutional, and individual influences that enable faculty decisions to engage in engineering education for sustainable development (EESD) and investigate how these influences vary across national contexts. Using Lattuca and Pollard's model of faculty decision-making (2016), this study answers the following research questions:

RQ 1: What individual, internal, and external influences support engineering faculty choices to integrate the SDGs in their courses?

RQ 2: How do the influences vary within and across sites?

With a pragmatic approach, I conducted an exploratory comparative case study across two institutions, one in Denmark and one in the United States, to understand the salient influences in the faculty decision-making process and how those influences may differ between sites. Using interviews of faculty who incorporate the SDGs in their engineering courses, interviews of key informants, document artifacts, and observations from each site to contextualize each case, I studied the factors influencing the decisions of faculty who are engaging in EESD. Given that engineering education for sustainable development looks different depending on the national context as well as the institutional or departmental culture, this approach allowed me to explore potential salient contextual influences, and how they may differ between sites.

A summary of the study design, which I explain and justify throughout this chapter, is shown in Table 3-1. In Section 3.1, I describe my worldview and how it has influenced my study design. Section 3.2 presents the comparative case study methodology in detail. Sections 3.3 to 3.7 elaborate on the data collection methods, pilot study, data analysis, research quality and ethics.

Study Design Component	My Approach
Epistemology	Pragmatic
Research Focus	Faculty decisions to integrate SDGs into engineering courses in US and Denmark
Methodology	A comparative case study using qualitative data sources and cross-case analysis (Merriam, 2007; Miles et al., 2019): • Data Sources: Interviews (faculty and informant), document artifacts, field observations • Data Analysis: A priori and inductive analysis for each case, followed by cross-case comparisons.
Theoretical Framework	Lattuca and Pollard's model on faculty decision-making in curricular change (2012)
Desired Impacts	Identify effective practices to enable and support faculty in EESD nationally

Table 3-1 Study overview

3.1. Epistemology and Influence on Research Design

As an engineering education researcher, I recognize that the research we do is surrounded by our beliefs, values, and assumptions. Because researchers are a part of the world we study, the researcher and the research are considered to be inseparable (Hatch, 2002). Our research interests and the methods we use to answer the questions we ask are influenced by our worldviews and experiences. By reflecting on my relationship to this research study, I can acknowledge how my epistemology and positionality have influenced the study design.

3.1.1. Epistemology

Epistemologically, I adopt a pragmatic worldview, which focuses on the research problem and uses the available approaches and methods that best understand the problem (Creswell & Creswell, 2022). While post-positivism assumes that reality exists but is only approximated, and constructivism operates from the assumption that multiple realities can be constructed, pragmatism does not argue about the nature of reality (Hatch, 2002; Morgan, 2014). Instead, pragmatists value the different approaches to conducting research inquiry based on the research problem and the desired outcome of the study (Frey, 2018; Morgan, 2014). This

pragmatic worldview aligns with the engineer in me, to first address the nature of the problem, and then find the frameworks and methods that offer viable pathways for solving the problem.

3.1.2. Positionality

As an engineer who has always been passionate about advancing technology to effect positive social change, I struggled when I realized that the industry was more motivated by financial gains and less affected by the negative socio-economic and environmental consequences. After an undergraduate engineering degree from a U.S. university and years of working in the industry, I was inspired to pursue my graduate degree at an engineering institute in India, where the research initiatives and advancements aligned with the United Nations Sustainable Development Goals (UN-SDGs). I then went on to teach undergraduate engineering students there in India and realized how important ethics and value-based engineering culture can be in developing the engineers of tomorrow. Through the university's multidisciplinary experiential learning program, I traveled to rural villages in India and guided students in the development and deployment of sustainable solutions for the challenges faced by the community. As an engineering faculty member, I also experienced challenges as I designed and implemented non-traditional educational experiences in my classrooms. Encouraging and enabling students to think beyond their disciplinary textbook knowledge to come up with practical solutions for real-world problems was one of the many challenges I faced as a new faculty. As a result, as a researcher, I find myself driven to understand the identity, motivation, and decision-making process of both engineering faculty and students as well as the interdisciplinary teaching and learning required to move towards engineering for humanity and sustainable development.

To this project, I bring different aspects of myself including my globe-trotting childhood, engineering background, and teaching experience. Having grown up in three continents, I have witnessed how culture plays a role in a nation's educational system. Because of this, I tend to look at issues on a global level and compare how different countries address various issues. My intrinsic motivation to contribute to society, my values related to social responsibility, and my research work in robotics and automation for humanitarian activities broadened my engineering skills to interdisciplinary applications. This research, along with my teaching experiences led me to realize how current practices in engineering education do not necessarily enable future engineers with the technical knowledge and interdisciplinary skills that are required to address grand challenges. Moreover, as a teaching faculty, I gained a faculty perspective on the intense workload and effort that goes into engaging students and spreading the joy of learning difficult concepts. All of these experiences relate to this project.

3.1.3. Influence on Study Design

My interest in engineering education for sustainable development is influenced by my experiences as an engineering student who wanted to contribute to society, as an engineer who was disillusioned by the industry, and as an engineering faculty who understood the challenges of creating a learning environment where future engineers could develop the required skills and attitudes to address the needs of the people and planet. Reviewing related literature led me to realize that most studies focused on effective pedagogies and student motivation, but only a few studied the facilitators of student learning and their role in this effort to incorporate sustainable development in engineering courses. From my personal experiences, I have observed that engineering faculty are typically recruited for their proficiency in technical knowledge and research, and not necessarily because of their passion for teaching or interest in developing the

engineers of tomorrow. I also appreciate the complexities of faculty decision-making based on my own experiences. I believe that engineers have a responsibility to society and that engineering educators have the responsibility to provide their students ample opportunities to understand the broader impacts of the engineering profession. These influences have thus shaped both my broad research area and the specific research questions for this study. In that sense, as a pragmatist, I began with the problem: how do we engage more faculty in EESD?

My epistemology and positionality influenced my study design in multiple ways. While my research focus stems from my positionality, views, and experiences, I have designed the study with a pragmatic approach. First, I have chosen to focus on understanding faculty who do engage in EESD because I am particularly interested in what is working; while studies that identify barriers can be useful, removing barriers does not guarantee success. Second, I chose a case study design because the case study approach emphasizes that phenomena are situated within broader contexts, and it is well-suited to examining real-life phenomena where the boundaries between the broader context and the specific phenomenon are not easily defined (Merriam, 2007). In this case, as the discussion in Chapter 2 indicates, faculty choices related to teaching are complex, ongoing processes that are shaped by a range of contextual factors. A case study design allows me to explore the context in more depth through the integration of multiple forms of data. The comparative approach study allows me to study educational phenomena in more than one country because of both my own experiences across living and working in multiple countries and the larger literature highlighting the role that national cultures and policies play in educational practice. Specifically, as described in Chapter 2, implementation of both the SDGs and EESD varies widely by country. Therefore, as a doctoral student working in a U.S. context, I anchor my study in the U.S., but chose to compare institutions based on national

context. Specifically, I studied how the influences enable faculty to incorporate the SDGs in engineering education at two similar institutions in countries that value SD differently. This design was useful to identify best practices that can be used to inform educational practices in the home country (Tang et al., 2023)(Tang et al, 2022). In addition, the findings from this study can be used to identify common supports and barriers in enabling faculty to practice EESD across both sites. This "ameliorative" approach to comparative case study design, typically preferred by pragmatists (Tang et al, 2022), serves as a key step in advancing EESD nationally.

3.1.4. Researcher Bias

Given that my experiences and experiences have influenced this study from the research question to the methods used, I acknowledge that my approach to this study is undoubtedly biased. However, by critically reflecting and recognizing my biases, I have worked to mitigate them and produce quality research. For example, one potential bias comes from the point that I have chosen to study like-minded people. By studying engineering faculty who include the SDGs in their teaching practices, it is easy to assume that they may share my values and beliefs about the role engineering plays in sustainable development. To ensure that this does not lead to me probing less during the interviews, I took measures to mitigate the researcher bias, which I elaborate upon in Section 3.7.

3.2. Theoretical Framework

This study uses the Lattuca and Pollard's model of faculty decision-making about curricular change (2016) to provide a lens to understand faculty decisions to incorporate the SDGs in their engineering courses. This framework serves two purposes in this study. First, it was used to develop the interview protocol, as described in Section 3.3. The questions were intentionally formed to elicit responses around the three influences of faculty decision-making.

Second, it informs the data analysis process, which is elaborated on in Section 3.5. In the initial round of coding, the interview data was analyzed to identify which influences are discussed by faculty and how they shape their decisions around incorporating the SDGs in their engineering courses. Additional rounds of analysis identified both emergent subthemes within the existing influences and new codes that depict other influences.

3.3. Case Development

Grounded in a pragmatic worldview, I conducted an exploratory comparative case study design that used Merriam's (2007) qualitative approach to develop the cases individually, and Miles et al., (2019) to compare the cases, as referred by Merriam. Case studies offer an approach to explore "a single phenomenon or a group of people in-depth" (Case & Light, 2011) and are a viable research methodology when questions, such as 'why', 'how', and exploratory 'what' are being asked by the research (Merriam, 2007). A case study is defined as "an intensive, holistic description and analysis of a single instance, phenomenon, or social" (Merriam, 1988, p. 27). A case study is well-suited to understand engineering faculty members' decisions to incorporate SD in their courses as this approach allows an in-depth exploration of the various influences behind the decisions. Since EESD is influenced not only by individual beliefs but the social contexts and national priorities towards SD (Ashford, 2004), a comparative case study enables me to identify what the influences are and how they vary across national contexts. A comparative case study explores the phenomena in more than one country and, typically, uses the country as the unit for comparative analysis (Tang et al., 2022). By selecting institutions in two countries, I was able to recognize the ways in which the institutions and faculty decisions are influenced by national policies and cultures. In doing so, this comparative education research "not only generates knowledge about education abroad but also has the potential to bring forward new insights on

education systems in the researchers' home countries" (Tang et al., 2022; p. 5). Thus, the potential impact of this study could be valuable in fostering sustainable development in the context of U.S. engineering education.

In this study, a case is defined as the group of engineering faculty at a particular institution who integrate the SDGs in their courses. As detailed further in Section 3.3.2, the case is not limited to any one department or engineering discipline, and participants self-identify with respect to what it means to integrate the SDGs. To develop each case, I adopted a qualitative approach by conducting faculty interviews, observing institutional and local practices, and analyzing relevant documents such as university websites, engineering programs and curricula, and course syllabi. With interviews of faculty who include the SDGs in their engineering courses, interviews of key informants, observations of the institutional and local culture, and document artifacts to contextualize each case, I studied the attitudes, values, and beliefs of faculty who are inclined towards EESD, as well as how the department, institution, and national contexts influence their decisions. In addition, this approach to case studies supports the use of theoretical frameworks that will guide the inquiry (Merriam, 1988; Yazan, 2015). For this study, I used Lattuca and Pollard's model of faculty decision-making about curricular change (2016) to provide a lens to understand faculty decisions behind incorporating the SDGs in their engineering courses with the broader goal to identify the salient influences required to bring about a change.

3.3.1. Site Selection

For this study, two institutions, one in the U.S. and one in Denmark, were selected to understand the salient influences and differences between sites in the faculty decision-making process, with national context as the primary variable. While faculty decisions to engage in

EESD may vary by individuals' values and beliefs, as well as by departmental and institutional culture, they also varies nationally as well. For example, as described in Chapter 2, the United States is doing well with certain goals such as the SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth), but due to the threats to biodiversity, and high levels of pollution and CO_2 emissions, in 2021, it ranked at 32 in the world for its performance towards the SDGs (Lafortune, 2019; Neve, 2021). This also correlates with the ad hoc approach American universities have in integrating SD in engineering curricula, as elaborated in the previous chapter. The Scandinavian countries, on the other hand, lead in their performance of the SDGs, with an SDG Index above 80 (out of a possible 100) (Are Countries Achieving the Sustainable Development Goals?, 2019; UNSDSN, 2021). This national performance is reflected in their education initiatives where universities such as KTH and Mälardalen University in Sweden and Alborg University in Denmark prioritize sustainable development in their curricula and research (Guerra, 2020; KTH Royal Institute of Technology in Stockholm, 2021; Mälardalens Högskola, 2021). Given that the U.S. lags behind a number of European countries, selecting a large public institution in the U.S. and Denmark for this comparative study can help both point toward potential explanations for the current implementation status in the U.S. and point toward opportunities for growth. Here, by selecting a case in the United States and a case in Denmark, the focus, I can study how two national contexts that prioritize the SDGs differently influence the efforts toward EESD. A summary of these two site selections is detailed in Table 3-2.

	Site 1: LP-US	Site 2: LP-D
Country	United States	Denmark
Country's SDG ranking	32	3
Institution Type	Public	Public
Established	1870s	1970s
Research profile	Very high research	Very high research

Highest degree offered	Doctoral	Doctoral
University's overall ranking	251-300	201-250
University's SDG ranking	90-100	1-10
Engineering ranking	75-85	75-85
Number of engineering programs	30	28
Number of engineering faculty	384	200 (approx.)
Number of engineering students	9,903	4,625

Table 3-2 Summary of site selection

3.3.1.1. Site 1: Large Public University in the U.S.

The first site, LP-US, is a large public land-grant university in the Eastern part of the United States. LP-US was selected because of its accessibility and convenience, but also its potential to yield transferable findings. It is typical of research-intensive land-grant institutions in the U.S. and is consistently in the top 10 institutions in the country in terms of the number of engineering degrees granted (e.g., Roy, 2018). According to the university's website, LP-US is "committed to sustainability" and is "well positioned to address these complex problems and contribute to the achievement of the SDGs through teaching, research, and service" (D-W01).

3.3.1.2. Site 2: Large Public University in Denmark

LP-D is a large public university in Denmark that shares several characteristics with LP-US such as its research orientation, type, and levels of degrees offered, making it a useful comparative case. Similar to LP-US, LP-D is committed to the UN SDGs as indicated by its website (D-W02). Additionally, LP-D was ranked among the top five in the Times Higher Education Impact Rankings in 2021, and, as noted above, has a strong institutional focus on ESD in a country ranked highly on the SDGs.

3.3.2. Primary Participant (Faculty) Selection

Given that little is currently known about faculty decisions regarding EESD, the case is broadly defined in terms of both integration of the SDGs and the engineering discipline. First,

rather than defining specific criteria regarding what it means to *integrate* the SDGs, I allowed participants to self-identify through recruitment (see Section 3.3); integration may be as minimal as mentioning it in one class to courses revolving around one or more SDGs. Second, I included all engineering disciplines. Both decisions reflected my choice to treat the U.S. as my primary focus for this exploratory study. In the U.S., as detailed in Chapter 2, EESD is not widespread, and thus likely to benefit from understanding factors that support EESD. While it may be more prominent in some institutions or departments more than others, the faculty and courses that include the SDGs are not consistently found across institutions or engineering disciplines, nor is the nature of the inclusions always clear or consistent. This variation made it challenging to find faculty who engage in EESD in a single institution or department. The challenge was exacerbated because I used the SDGs to operationalize SD and treating the inclusion of the SDGs in particular as an indication of faculty engaging in EESD. Therefore, given the limited number of engineering faculty that include the SDGs in their teaching, and the variations in those inclusions, particularly in the U.S., it was more feasible to look at engineering faculty as a collective group and rely on participants' self-definition of whether they include the SDGs in their teaching. In addition, disciplines within engineering can look different depending on the national context. Given that this is a comparative study, limiting to a single sub-discipline was inconvenient. Moreover, choosing the collective group of engineering faculty across sub-disciplines as the case allows me to identify potential differences in departmental or disciplinary cultures within an institution that may be relevant. For this comparative case study, I extended this design choice to the Denmark case. The justification for Denmark, as well as for the two sites selected, is detailed in Section 3.3.2. This decision ensured that my scope is not too narrow (single engineering department) given the number of potential participants, nor too broad

(multiple institutions) given the potentially confounding factors that make comparison challenging.

3.4. Data Collection

Each case was developed using four data sources, as shown in Figure 3-1.

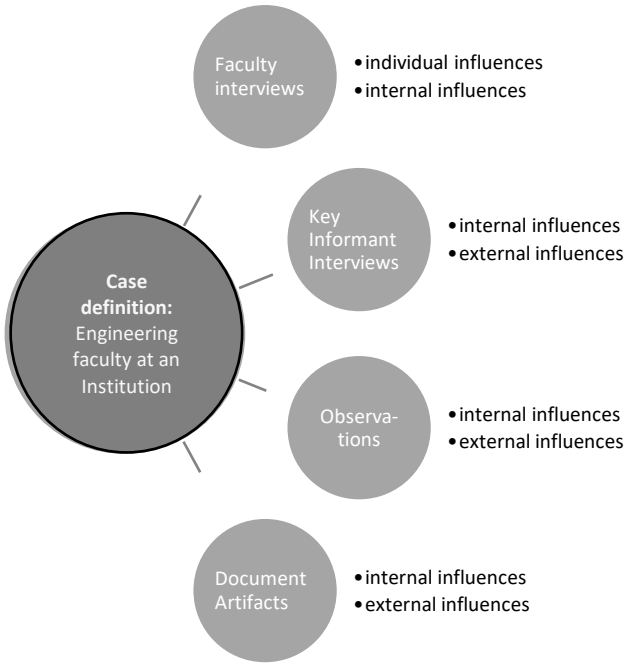

Figure 3-1 Case definition and data collection

The four forms of data collected from each site include the following: 1) interviews of 5-7 engineering faculty who self-identify as including the SDGs in their courses; 2) artifacts including university websites, program descriptions, and course syllabi; 3) observations of the related institutional and local practices and 5) interviews with 1-2 informants on national and institutional policies and culture. Given my study's focus on investigating faculty decisions to practice EESD, semi-structured interviews with the faculty who choose to incorporate the SDGs in their courses are the primary source of data. In addition, as the Lattuca and Pollard model (2012) suggests that these decisions are influenced not only by the individual but by the external and internal environments, to further understand the national and institutional context, I

incorporated interviews with key informants in order to gather necessary context about how these environments support faculty decisions to include the SDGs. Furthermore, document artifacts, such as university websites, program descriptions, and course syllabi allowed me to explore how SD is discussed and included in the part of the institution and department's vision and values. The total data collected is summarized in Table 3-3.

	Faculty interviews	Key informant interviews	Document artifacts
LP-D	5	2	~27
LP-US	7	3	~21

Table 3-3 Total data collected

3.4.1. Faculty Interviews

Qualitative interviews of engineering faculty were the primary data source for this study. Using snowball sampling, I recruited 5-7 engineering faculty from each site who incorporate the SDGs into their courses (Merriam, 2007). The participant selection criteria were not restricted to any specific engineering department, gender, or race. The semi-structured interviews were designed to last about one hour. Interviews were primarily collected in person, with exceptions for participants who requested to meet over Zoom.

3.4.1.1. Participant Demographics

At LP-D, a total of 5 engineering faculty and 2 key informants were interviewed. Of the 5 faculty, 3 were male and 2 were female. At LP-US, a total of 7 engineering faculty and 3 key informants were interviewed. The participants were drawn from a range of different engineering departments at each institution, including Energy, Bioscience and Chemistry, IT and Design, Civil Engineering, Biological Systems, Minerals and Mining, Material Science, Construction, and STEM Education. The department names are slightly modified here to protect the confidentiality of the participants as naming the department could make the institutions, and particularly participants, identifiable.

3.4.1.2. Recruitment

Recruitment leveraged the site coordinators at each site and relied on snowball sampling as needed. Through professional networks, a site coordinator (an academic faculty member or administrative staff member)at each site was identified. Identifying site coordinators was useful to ensure that the necessary approvals were acquired at each site. In addition, site coordinators helped to identify and refer potential participants. Since I looked specifically at engineering faculty who integrate the SDGs in their course, the site coordinators were able to provide a starting point for the recruitment process. Moreover, site coordinators facilitated the distribution of the recruitment email (Appendix A) especially in cases where emails from an internal address are more likely to receive a response. While site coordinators may recommend faculty who *integrate* the SDGs, ultimately it is up to the faculty to self-identify and participate in the study. Through initial recommendations from the site coordinators and snowball sampling, I was able to recruit 5 participants at LP-D and 7 participants at LP-US.

3.4.1.3. Interview Protocol

To ensure that the interviews effectively captured the internal, institutional, and external influences of faculty decision-making, the interview protocol was developed based on the components of Lattuca and Pollard's model (2016), tailored specifically to decisions related to EESD. Table 3-4 details how the interview protocol was developed with reference to the theoretical framework to ensure the research questions were addressed. The full faculty protocol can be found in Appendix B.

Interview Prompt	**Theoretical Influence**
To start off, could you tell me about your background? • Educational background • Work experience • Years of teaching • Current role and research interests	Individual (identity, experiences)

Interview Prompt	Theoretical Influence
I would like to understand your perspectives on sustainable development. How do you define sustainable development?	Individual (knowledge and beliefs)
How do you describe the relationship between sustainable development and engineering? Why is this relationship important, particularly in your teaching?	Individual (knowledge and beliefs)

Next, I would like to know more about the courses you teach and your experiences teaching them.
Could you tell me about a course in which you've included the SDGs (or planning to integrate them if you aren't currently including them)?
- Why did you choose that course *(to incorporate the SDGs)*? What factors do you consider?
  o Is it a required course or an elective?
  o How long have you taught the course?
  o When did you decide to add in the SDGs – when you first taught it or later?
- Which SDGs are incorporated?
  o How and why did you select those?
  o How do you include the SDGs in the course?
  o Where do you not integrate the SDGs? Which topics, and why not?
- What do you want your students to gain from your courses *(as related to SDGs)*?
- What challenges have you faced in the course designed with SDGs? How do they differ from other courses?
- Will you continue to incorporate the SDGs into that course? Why?
- What kind of feedback have you received from students who have taken your course?
  o How are student responses to the SDGs in engineering?
  o How do those responses influence your teaching?
	Individual
	(experiences, knowledge, and beliefs)
	
	Internal
	(institution, department)

Are there other courses you teach where you incorporate the SDGs? If so, how are they similar to and different from the course you just described?	Internal (institutional, department)
How does integrating the SDGs into teaching align with your research, career goals, personal goals?	Individual, Internal
Now, I want to understand the departmental and institutional culture. How does sustainable development or the SDGs show up in the culture of the institution? - What are some examples of practices that make this evident? - How does it affect the faculty, staff, and students? - How would you like it to be? What should it look like? Why?	Internal/Individual

Table 3-4 Faculty interview questions and contribution to data

3.4.2. Key Informant Interviews

The key informant interviews provided additional context to each case. More specifically, their perspectives offered insight into the national policies and institutional culture.

3.4.2.1. Recruitment

I sought 2-3 key informants to participate in this study. Key informants were considered if they had either an administrative or teaching role at the research site. They were identified by their roles and responsibilities in the university, such as providing direction for the education and research practices, and/or implementing local, state and national regulations and policies in the university. That is, key informants were individuals who have sufficient understanding of the institution to help provide insights regarding institutional approaches to curricula and to faculty generally as well as to sustainable development and ESD in particular. Similar to the recruitment strategies used for faculty interviews, I referred to the site coordinators to identify experts who can provide the required background information and context for each site.

3.4.2.2. Interview Protocol

The key informant interview protocol was designed to capture the internal and external influences that may affect faculty decisions to incorporate the SDGs. Table 3-5 details the how the theoretical framework and research questions informed the interview protocol. The full protocol can be found in Appendix C.

Interview Prompt	**Theoretical Influence**
To start off, could you tell me about your background? - Educational background - Current role in the university	Internal - Institutional (culture, vision)
What informs or influences the university goals, values, and culture? - National policies and culture? - Labor markets, industry demands?	Internal - Institutional (culture, vision)
How does sustainable development fit with the university goals, values, and culture? - Where is this seen? - Why is it so?	Internal (departmental and institutional)
How is the university vision with respect to the sustainable development goals communicated to departments? - How is it reflected in the engineering curriculum? - How is it reflected in faculty career/promotion paths? - What are the biggest challenges and/or criticisms? - What is working well? - What are areas of improvement?	Internal (departmental and institutional)

Interview Prompt	Theoretical Influence
In what ways does university administration/institution support faculty including the sustainable development goals into courses if they know? - How does the university view the integration? - How are they rewarded, supported, and/or aligned with the department/institution vision? - Why is it supported/not supported?	Internal - (departmental and institutional)
What expectations do the engineering workplaces in the country have of their young hires? How might this relate to working towards sustainable development?	External (national policies)

Table 3-5 Key informant interview questions and contribution to data

3.4.3. Document Artifacts

In addition to the faculty and key informant interviews, I used document artifacts including university websites, program descriptions, and course syllabi used by interviewed faculty. Relevant artifacts were identified by a thorough search of the university website and publicly available articles of each site. In addition, I asked the faculty to provide any related documents, such as the syllabus they use. These documents provided additional information on departmental and institutional culture. Using the document artifacts, I was able to triangulate the findings from the faculty and key informant interviews. This was especially useful to identify consistencies or inconsistencies between the different perspectives.

3.5. Pilot Study

A pilot study was conducted at the LP-US sites to ensure that the interview protocol is eliciting relevant information. The interview protocol was piloted on faculty outside the College of Engineering who integrated the SDGs into their teaching. These pilot participants were identified through site coordinators or personal contacts. The data were transcribed and analyzed to identify any needed modifications the interview protocol may require and test the analytic approach. Data collection and analysis from the pilot study allowed me to test the alignment between the theoretical framework and the interview protocol. The preliminary results indicated that the initial interview protocol elicited the individual influences more than the internal and

external influences. Based on these results of the pilot study, modifications were made to probe more on how departmental and institutional culture informed faculty decisions, and how the external factors influenced their choices. Additionally, after an initial round of interviews at the Danish site, the interview prompts were adjusted to make explicit critical questions around decision-making.

3.6. Data Analysis

My analysis process followed Merriam's (2007) approach to qualitative case study research and, as suggested by Merriam, used Miles et al., (2019)[1] approach to compare cases across sites. Merriam (2007) describes the data analysis as "the process of meaning making," which involves data consolidation, data condensation, and data display. The within-case analysis involved the process of data consolidation and condensation, which was then followed by a cross-case analysis. Then, I used techniques to display the data and summarize my findings within and across cases. My approach to data analysis is summarized in Figure 3-2.

[1] Updated version of the Miles and Huberman (1994) that Merriam (2007) refers

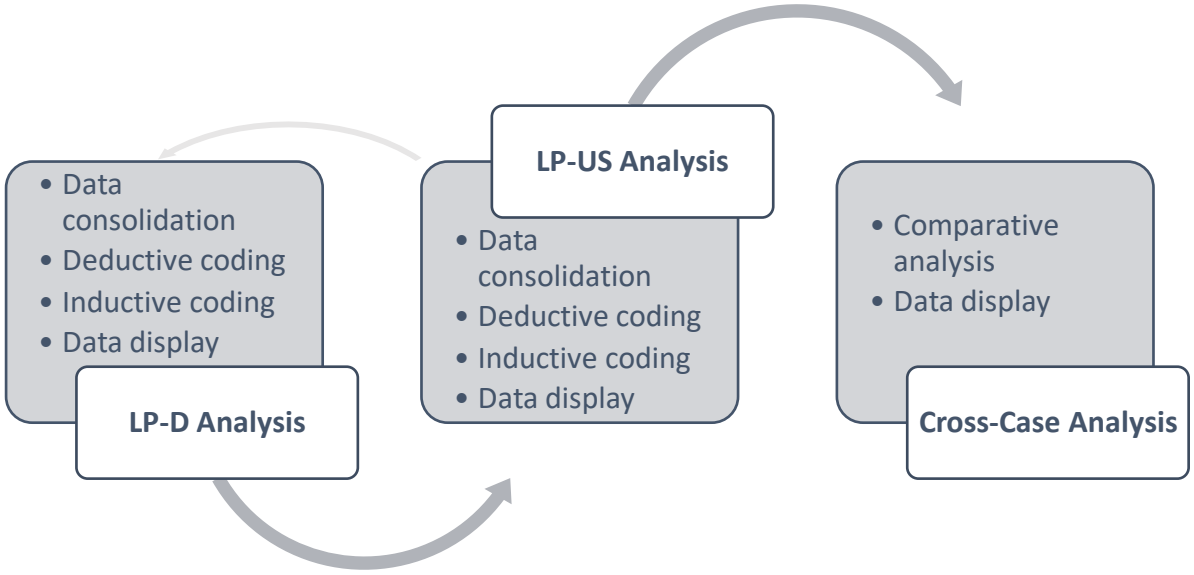

Figure 3-2 Overview of data analysis

3.6.1. Within-case Analysis

I began my within-case analysis by consolidating data, which involved organizing and synthesizing all the different forms of data—interview transcripts, observation notes and photos, document artifacts—together to present a primitive narrative of what was discovered in the data (Merriam, 2007). I sorted through the data, including the faculty interviews, key informant interviews, observation notes and documents, to organize the documents that supported (or did not support) the transcript data. If participants referred to specific national policies or programs at the institutions, I searched for documents or websites that provided more information about them. At this phase, the collected data was organized, and redundancies were sorted for the next phase of analysis.

Data condensation involved “selecting, focusing, simplifying, abstracting, and/or transforming the data” (Miles et al., 2019, p. 8). This phase included data categorization (Merriam, 2007), wherein the collected data is deductively or inductively condensed to identify emergent patterns or categories. Using the qualitative data analysis software MAXQDA, I conducted a first cycle of deductive coding, or a priori coding, using the Lattuca and Pollard (2016) framework of faculty decision-making on the faculty and key informant interviews. This step allowed me to condense the interview transcripts into data relevant to external, internal and individual influences. This was followed by a second cycle of coding, where I inductively reviewed the coded data to identify emergent subcodes within the three influences. Through this technique of pattern coding, I condensed the data further, which helped in refining my analysis and make meaning from my data (Merriam, 2007; Miles et al., 2019).

The document and observation analysis involved deductive coding based on the codebook that I was developing for the interview analysis. The documents and observations acted more as supporting material for the coded excerpts in the interview transcripts. For example, if the engineering program description specifically included a course or project on the SDGs, it was used to support the internal influences on faculty curricular choices. However, the language or content within the documents was not coded.

Through the stages of data consolidation and condensation, I was able to interpret the data from each site individually and identify patterns and themes that emerged specifically for each case. As captured in Figure 3-2, the within-case was an iterative process, and going through multiple iterations of the analysis informed the cross-case analysis.

Deductive Coding

I started with deductive coding the interview data using the three influences defined in the Lattuca and Pollard (2016) model. Using the definitions described in Table 3-6, I coded excerpts of the faculty and informant interviews. During the first round, I started noticing sub-influences and the interactions between the influences and added memos to capture both. In addition, upon completing the first round of coding, I realized that the influences I had coded were not all supporting influences. Some influences acted as barriers in faculty choices to engage in EESD. I addressed these in the second round of deductive coding to capture supporting and counteractive influences within each type of influence.

Code	Definition
External	Factors originating outside of the institution, such as national policies, industry trends, cultural practices, etc.
Internal	Factors within the institution, such as institutional policies, culture, mission, etc.
Individual	Factors related to individual faculty members, such as identity, experiences, knowledge, and beliefs

Table 3-6 Initial codebook based on Lattuca and Pollard model (2016)

Inductive Coding

After completing deductive coding, I went through each influence to identify the sub-influences. Using MAXQDA, I was able to add multiple codes for excerpts. This was especially useful to identify the interactions between influences. At this stage, I went through multiple iterations of inductive coding to refine the sub-influences. The codes in each sub-influences were analyzed in detail to determine consistency and relevance. I also looked for intersections and overlap among the sub-influences, allowing me to identify broader themes and interactions between influences.

The salience of an influence was determined based on the frequency of its presence across the interviews. Specifically, an influence that appeared in at least 75% of the interviews was considered salient and was included in the findings. Furthermore, I assessed the strength of

each influence based on the depth and richness of the descriptive data associated with it. Both direct statements citing an influence as important and thicker portrayals, characterized by more elaborate and detailed descriptions, indicated a stronger influence within the context of the study. The strength of influence was also highlighted when the interactions between influences emerged in the rich detail and explicit connections participants made. The final codebook is presented in Table 3-7.

Code		Definition
External	Government policies	Government laws or political climate
	Industry engagement	Industry involvement in teaching and research, and employability expectations
	Funding agencies	Entities providing financial support; includes public and private agencies
	Cultural norms	Global or local societal norms and trends
	Industry demand	Industry demands and employability expectations
	Evaluation systems	External evaluation systems such as accreditation boards or ranking systems
	Globalization	Interaction and integration among people, companies, and governments worldwide
Internal	Institutional mission	Institutional mission, vision and culture
	Institutional culture	Internal environment and rewards related to faculty recognition and promotion
	Programs and course offerings	Programs (institution-level) or courses (department-level) offered
	Pedagogical approach	Teaching and learning practices adopted within the institution
Individual	Beliefs of SD and Engineering	Beliefs of SD and Engineering
	Previous experiences	Previous experiences
	Beliefs about goals and values of education	Beliefs about goals and values of education

Table 3-7 Final codebook

3.6.2. Cross-Case Analysis

Once the within-case analysis for both sites was complete, cross-case analysis was conducted to trace across both sites to identify similarities and differences. A cross-case analysis

was useful to see what influences faculty decisions to engage in EESD across both these sites and to understand how these influences are "bent by specific local contextual variables" (Merriam, 1988; Miles et al., 2019). This comparison allowed me to answer the second research question and understand how the influences of faculty decisions to engage in EESD varied across sites, in relation to the contexts of both institutions in the US and Denmark. While there were some similarities in the salient influences that emerged from the data, there were differences in how the influences acted on faculty decisions. These similarities and differences were captured using matrices.

3.6.3. Data Display

During the data display phase, I summarized the findings within and across both cases and present them visually. I used tables and interaction maps to present my findings. The tables were useful to present all data and findings clearly, which was especially useful for the cross-cass analysis (Miles et al., 2019, p. 105). This technique may be especially useful to summarize findings from the within-case analysis. Alternatively, the interaction map acted as a "collection of nodes or binds connected by links or lines that display streams of participant actions, events, and processes" that was particularly effective for tracing the relationships between influences (Miles et al., 2019, p. 109) and providing a visual representation of the influences and interactions. The final versions of these tables and maps appear in Chapter 4 as part of the results.

3.7. Research Quality

Ensuring the quality of research is crucial to producing valid and reliable knowledge. In case study research, Merriam (2007) recommends addressing three criteria for judging quality in case studies: internal validity, reliability, and external validity. Note that while other methods

used in engineering education research often use terms such as “trustworthiness” rather validity and reliability to discuss quality in qualitative methods, in this study I have chosen to adopt Merriam’s language because her work is the primary source for my methodology. As Merriam uses the term, internal validity deals with ensuring whether the findings match reality and whether the methods are designed to measure what the researchers intend to measure (Merriam, 2007; Miles et al., 2019). In qualitative research, addressing internal validity involves addressing the researchers’ role as they interpret the data. Thus, specific measures need to be taken to ensure internal validity. Reliability refers to “the extent to which one’s findings can be replicated” (Merriam, 1988, p. 170). Here again, the challenge lied in separating the my interpretations from the knowledge that is produced, and measures must be taken to ensure the reliability of the results. Merriam uses external validity to address the generalizability of the research results – what engineering education researchers typically refer to as “transferability” in qualitative research. Generally, case studies have high external validity as they study a phenomenon in depth and detail. It is important to note that the goal of case study research was not statistical generalizability. Case study research was selected for this dissertation study to understand the case in depth, not to know the truth of many cases. While experts of case study research argue that generalizability is an inappropriate goal, multi-case studies or comparative case studies may enhance the transferability (usefulness of findings) or external validity of the research. Thus, through a comparative case study, I aimed for analytic generalizability, wherein the research expands and generalizes theories as similarities across the two cases are identified.

To ensure and enhance the quality of this comparative case study research, I used a range of strategies that address these three critical components of qualitative case study research detailed in Table 3-8.

Criteria for Research Quality	Measures and Strategies to Ensure Quality
Internal validity	• Triangulation • Peer debriefing
Reliability	• Peer debriefing • Interview memos • Audit trail
External validity	• Providing rich, thick description of case and context • Conducting cross-case analysis

Table 3-8 Strategies to ensure research quality

3.7.1. Data Triangulation

The main focus of this study is faculty perspectives on their decisions to incorporate the SDGs in their course. The study, therefore, relied primarily on faculty interviews. By conducting interviews with key informants and collecting their perspectives on the external and institutional culture, I was able to identify consistencies or inconsistencies between these two perspectives. In addition, the university websites, engineering degree program guides, and other document artifacts provided an additional perspective of how the university presents its culture and values to the public. These different perspectives allowed me to triangulate the findings from the faculty interviews, thereby working to ensure the internal validity and reliability of the study.

3.7.2. Peer Debriefing and Coding Reviews

In this study, I involved peer researchers to go through my codebook, code a subset of data, compare codes and review my findings. This process of peer debriefing challenges my assumptions as the researcher, by asking further justifications for my interpretations. By including other researchers to review my coding process, this process helped assess consistency and establish credibility and trustworthiness.

3.7.3. Interview Memos

I used analytic memos (Hatch, 2002) to record my observations, possible themes, and the correlations between these themes and my theoretical framework. This practice ensured that even

with time my insights and interpretations remained intact. After each interview, I wrote memos or recorded voice memos to capture the interesting details and to make a note of any significant themes I noticed across interviews. These analytic memos can help boost the reliability of this study as I document my perceptions of interpretations of the data.

3.7.4. Audit Trail

To further ensure the reliability of my research, I engaged in reflexivity, the process of "continual internal dialogue and critical self-evaluation of researcher's positionality as well as active acknowledgment and explicit recognition that this position may affect the research process and outcome" (Berger, 2015). By documenting this continuous self-assessment of my position and its influence on my research using a research journal, I was able to intentionally identify my decisions and thought processes as I engage in data analysis. This audit trail (O'Brien et al., 2014) "increases the dependability of the process of interpretation" (Bourke, 2014). Through these measures, I continued to be reflexive and transparent to myself and my audience about my biases and their influence on my study.

3.8. Limitations

There were several limitations to this study. One limitation of this comparative case study design was the limited number of cases. While Merriam (2017) does not suggest a specific number of cases for multiple case studies, she does state that more cases would strengthen the external validity of the findings. In my design, studying the faculty at a single institution in each country limited me in how much I can attribute the findings to national contexts. Thus, it is important to acknowledge that this is an exploratory study to understand faculty decision-making in EESD. In addition, because recruitment methods include snowball sampling participants, I was able to access a subset of engineering faculty who engage in EESD at both institutions. To

address this limitation, I sought at least 5-7 participants at each site and supplement the faculty data with relevant documents, observations, as well as interviews with key informants at each site. This triangulation measure allowed me to capture a larger perspective of faculty decision-making that includes institutional and national influences.

4. Findings

In this chapter, I answer the two research questions posed in this study:

RQ1: What individual, internal, and external influences support engineering faculty choices to integrate the SDGs in their courses?

RQ2: How do the influences vary within and across sites?

In order to situate the findings, I first provide a contextual description for each institution in Section 4.1. In Section 4.2 and 4.3, I answer RQ1 by describing the most salient influences found in each case. Finally, I compare the findings across both sites in order to answer RQ2 in Section 4.4. Note that to maintain the de-identification of the two institutions, relevant institutional documents are cited by number only; a key linking the document numbers to the full citations has been maintained in the audit trail for this study but is not released in publications.

4.1. Contextual Site Descriptions

4.1.1. LP-D Site

LP-D is a public research university with multiple campuses in Denmark. It was founded in the 1970s as a polytechnic institution with a focus on engineering and technical sciences. LP-D is a well-regarded university with a strong reputation for research and innovation, especially in areas such as energy, sustainability, health, and information technology. One of the leading universities in Denmark, LP-D is known for its strong commitment to sustainability, with a number of initiatives aimed at reducing its environmental impact and promoting sustainable practices. The university has received several awards for its sustainability efforts, including recognition as a green campus. Pedagogically, LP-D relies heavily on problem-based learning, and all courses across the university include significant problem-oriented methods in project work.

4.1.1.1. National Context

Denmark is committed to sustainable development and has implemented a number of policies and initiatives to reduce its carbon footprint and transition to a green economy. This commitment is reflected in the country's national policies and funding opportunities, as well as its participation in the broader European context. At the national level, the Danish government has set ambitious targets to decrease greenhouse gas emissions and attain a carbon-neutral society (Fuinhas et al., 2023). The Danish Climate Law, which was passed in 2019, sets a legally binding target of reducing greenhouse gas emissions by 70% by 2030, compared to 1990 levels, and achieving net-zero emissions by 2050 (Fuinhas et al., 2023). In addition, the country has a carbon tax, which incentivizes businesses and individuals to reduce their greenhouse gas emissions (Lenain, 2022). Denmark has also invested heavily in renewable energy sources, such as wind power, and has set ambitious targets for reducing energy consumption and increasing energy efficiency (Kany et al., 2022; Lenain, 2022; Ravn Boess et al., 2021). In addition to its domestic efforts, Denmark is also active in promoting sustainable development and climate action on the global stage. The country was an early adopter of the SDGs and has played a leadership role in promoting them through international cooperation and development aid (Ravn Boess et al., 2021). The Danish government also provides funding opportunities for research and innovation related to sustainable development and climate change. For example, the Innovation Fund Denmark and the Danish Council for Independent Research provides funding for research and development projects that “show commitment to the common good, transparency, ethical conduct and education and training of new researchers and graduates” (Fund it, n.d.) in a range of areas, including sustainable development and climate change (Independent Research Fund Denmark, n.d.).

As a full member of the European Union (EU) and a signatory of the Paris Agreement, Denmark is an active participant in efforts to promote sustainable development and address climate change. The EU has set a goal of achieving net-zero greenhouse gas emissions by 2050, and Denmark is working to align its national policies with this goal. Denmark is also a member of the Nordic Council, which is committed to promoting sustainability and addressing climate change in the Nordic region (Nordic Co-operation, 2023). In addition, the European Union provides funding opportunities for research and innovation related to sustainable development and climate change. For example, Horizon Europe is a funding program that supports research and innovation in a range of areas, including sustainable development and climate change (*Horizon Europe*, 2023). Overall, Denmark's geographic, sociocultural, and political context is characterized by a strong commitment to sustainable development and climate action, reflected in both its domestic policies and its international engagement.

4.1.1.2. Institutional Context

As an institution, LP-D has made significant efforts to contribute towards achieving the United Nations Sustainable Development Goals (SDGs). The university has recognized the importance of addressing sustainability challenges and has incorporated the SDGs into its teaching, research, and outreach activities. Through its problem-based learning approach, the engineering curriculum in LP-D includes SDGs as focus areas for the early undergraduate years. The university also offers sustainability-specific programs at a graduate level. In addition to its research and teaching activities, LP-D has taken steps to promote sustainability on its campuses. The university has implemented a number of initiatives to reduce its environmental impact, such as reducing energy consumption and waste generation, promoting sustainable transportation options, and using renewable energy sources. LP-D has also been active in promoting

sustainability and the SDGs through outreach activities. The university has established partnerships with businesses, NGOs, and other organizations to promote sustainability and share knowledge and best practices. Overall, LP-D's initiatives towards the SDGs demonstrate a strong commitment to sustainability and a recognition of the importance of addressing sustainability challenges at the local and global level. Through its research, teaching, and outreach activities, LP-D is making valuable contributions towards achieving the SDGs and creating a more sustainable future.

4.1.2. LP-US Site

LP-US is a large public land-grant university situated in the Eastern part of the United States. As a land-grant institution established in the 1870s, LP-US's primary objective was to provide education in agriculture, engineering, and other practical fields. Today, the university has grown to become one of the largest in the country, with a student population numbering over 35,000. According to the Carnegie Classification of Institutions of Higher Education, LP-US is considered to be doctoral university with very high research activity. As a land-grant university, LP-US has a special mandate to serve the broader state community, and it does so through a range of outreach programs and partnerships with local businesses and organizations throughout the state. Engineering programs at LP-US employ a fairly traditional approach, with project-based courses in the first and final years, and lecture- and lab-based technical courses in the middle years.

4.1.2.1. National Context

The socio-cultural and political context of the United States with respect to sustainable development, the U.N. SDGs, and climate change is complex and multifaceted. On one hand, there is a growing awareness and concern about the impacts of climate change and the need for

sustainable development practices reflected in public opinion polls, which consistently show that a majority of Americans believe in the reality of climate change and support policies aimed at reducing greenhouse gas emissions and promoting renewable energy (Poushter et al., 2022). The United States has also been a signatory to international agreements such as the Paris Agreement, which commits countries to take action to limit global warming (United Nations, 2015a). At the same time, there are significant political and cultural barriers to making progress on sustainable development and climate change. The United States has a highly polarized political climate, with significant disagreements between political parties and interest groups on issues such as environmental regulation and climate change policy; under Donald Trump's Republican presidency, for example, the U.S. withdrew from the Paris Agreement. This polarization has led to a lack of national-level policy action on climate change, despite growing scientific evidence and increasing public concern (Fiorino, 2022). Additionally, cultural factors hinder progress on sustainable development and climate change. For example, the strong emphasis on individualism and consumerism in the United States makes it difficult to implement policies that require collective action or lifestyle changes (Banerjee et al., 2022; Vishnubhatla & Agashe, 2022). There is also a history of skepticism and distrust toward science and scientific institutions, which can make it challenging to build public support for policies that are based on scientific evidence (Bugden, 2022; Sarathchandra et al., 2022). The nation's divided political and socio-cultural climate is reflected in the slow progress toward sustainable development initiatives in comparison to other developed nations, as the U.S. ranked 32, 41, and 39 in 2021, 2022, and 2023, respectively, in the Sustainable Development Report (Sachs et al., 2022; *Sustainable Development Report 2021*, 2021; *Sustainable Development Report 2023*, 2023).

Despite the challenges, efforts are taking place across the United States that often involve partnerships between government, industry, and civil society to address the specific needs and challenges of different communities and regions. Land-grant universities such as LP-US are one example of partnerships where national policies and funding agencies drive research efforts and education initiatives toward sustainable development. A more recent example is the Infrastructure Bill, also known as the Infrastructure Investment and Jobs Act, which was introduced in August 2021 under a Democratic president and a Democratic congressional majority (United States Congress, 2022). The bill allocated approximately $5.5 billion over five years on a range of infrastructure projects, including funding for a range of climate change initiatives, such as investments in renewable energy and electric vehicle infrastructure. These investments benefit universities, including LP-US, that are researching or developing clean energy technologies. In addition, the Inflation Reduction Act of 2022 aims to reduce inflation by investing in energy security and climate change. Thus, as the impacts of climate change become increasingly urgent, there is evidence of efforts at the national level that indicate sustainable development is a national priority.

4.1.2.2. Institutional Context

Consistent with the widespread public concern over climate change, in recent years LP-US has taken significant steps to reduce its environmental impact and promote sustainability on campus and beyond. The university has implemented a number of energy-saving measures, such as installing solar panels and upgrading to more efficient lighting systems (US-W02; US-W03). LP-US also offers several programs and courses related to sustainability as standalone programs or optional certificates, such as a minor in green engineering pathway (US-W04). Overall, there are efforts in research and education on sustainable development at LP-US.

LP-US is also recognized as a land-grant university that has a strong focus on international outreach and collaboration (US-W05). Through its global education office, LP-US provides a wide range of opportunities for students to study and conduct research abroad while welcoming international students and scholars to its campus. As a land-grant university in the 21st century, LP-US recognizes the importance of addressing global challenges such as climate change, food security, and poverty (US-W05), and sees its land grant mission as extending globally. To this end, the university has established partnerships and collaborations with institutions and organizations around the world, working together to develop innovative solutions and share knowledge and expertise. LP-US's land-grant mission also emphasizes the importance of community engagement and service, both at home and abroad. Through its international outreach programs, the university works with communities around the world to promote sustainable development, improve access to education and healthcare, and address other pressing social and environmental issues (US-W06). Overall, LP-US's status as a land-grant university underscores its commitment to using education and research to make a positive impact on the world.

4.2. Findings at LP-D

At LP-D, several external, internal and individual influences affected faculty decisions to engage in EESD, with external and internal influences the most prominent in data. As shown in Figure 4-1, these influences interacted with each other as well.

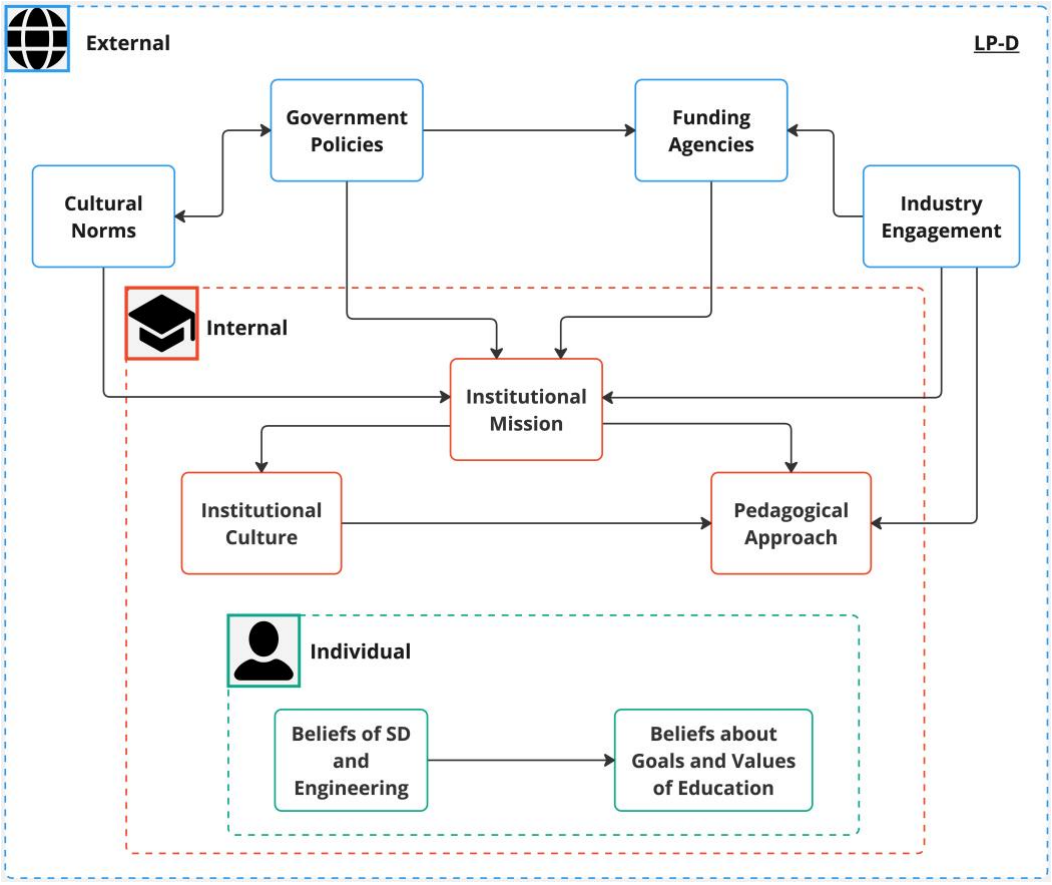

Figure 4-1 Summary of salient influences at LP-D

External influences included national policies, funding agencies, industry engagement, and cultural norms. Internal influences included institutional mission, organizational reward structure, and departmental or disciplinary culture. Individual influences, though discussed less frequently by participants, included beliefs of engineering, sustainable development, and the relationship between the two, teaching beliefs and experiences prior to their current faculty position. Additionally, several interactions between the findings emerged from the data. For example, national policies influenced funding agencies which influence institutional mission and the organizational reward structure. The dotted lines in the figure highlight the ways in which different levels do (and do not) implicitly influence one another. Thus, although there are no direct lines from specific external influences to individual ones, the position of the individual

dimension within the external one points to the implicit, indirect links between the two that emerged in the data. The following sections describe each influence in more detail.

4.2.1. External Influences

Several external influences, or factors that originate outside of the institution or organization, emerged from the faculty and key informant interviews. At LP-D, the salient external influences that affected faculty choices to engage in EESD were government policies, funding agencies, industry demands, and cultural norms, which are defined in Table 4-1.

External Influence	Definition
Government policies	Government laws or political climate
Industry engagement	Industry involvement in teaching and research, and employability expectations
Funding agencies	Entities providing financial support; includes public and private agencies
Cultural norms	Global or local societal norms and trends

Table 4-1 Definitions of external influences at LP-D

While not every external influence was present in every faculty interviews, all were prominent across the data and the key informant interview addressed each one as well as how the influences interacted with each other. In addition, document artifacts of the policies referred to by the participants as well as observations of the local context of LP-D supported these findings. The presence of each of these influences in the interviews is shown in Table 4-2.

	Funding agencies	National policies	Industry Engagement	Cultural norms
F1	X		X	X
F2	X		X	
F3	X	X	X	
F4	X		X	X
F5	X	X	X	X
KI	X	X	X	X

Table 4-2 Salience of external influences across participants at LP-D

4.2.1.1. Government Policies

The influence of government policies in EESD decisions showed up in a number of ways. Participants discussed how policies shaped external funding opportunities in Denmark and Europe, as in the following comment describing the influence of government policies:

> External funding, again, follows all these new directives. That we need to be, I don't know, 100% renewable by 2050, and maybe 50% renewable by 2030. And all these big goals politicians make and decide. So we follow on those, because the funding calls are also related to these. So with research, we're very much linked to these directives, these calls. (D-F03, Pos. 191)

Faculty also discussed how these funding calls and their resulting research informed their teaching practices, through examples they use in the classroom, through student projects they guide, and even in the courses offered at LP-D. One faculty member explained the link as follows:

> When we talk about courses, well, a lot of the courses are linked to research. I mean there are certain basic courses where – the basic stuff. But we try to keep updating the content of the course. (D-F03, Pos. 191)

In some instances, policies also informed the context and the need for specific student projects. One of the key informants provided an example of how government policies play a role in the renewable energy system. On a day of heavy winds, wind power can generate 140% of Denmark's electricity demand (Neslen, 2015). Because Denmark lacks the capacity to store excess energy, it is currently exported to other nations for free. Thus, sector coupling is a political issue that is also dependent on technology and research initiatives. As the management at LP-D work with government agencies, private companies and NGOs for strategic partnerships that facilitate the research and development initiatives for the advancement of the country, these projects also impact student education opportunities, as one participant explained with specific reference to the government policies on sector coupling and the related research efforts:

> And coming to education, we involve our students in everything that I just said [about sector coupling]. So I was talking about research. But whenever I say

> research as a duality to education because our education is research-based education. And as I'm 100% sure, we have this particular problem-based curriculum model that we have been developing for more than 40 years. And so that's the main instruments on the educational side to activate the potential in the 50% of the education, roughly. (D-K02, Pos. 4)

In this case, the research challenges in wind energy formed the basis for student projects in the faculty member's course.

Policies also influenced the educational practices at the primary and secondary school levels, which played a role in the cultural norms and expectations of incoming students at LP-D. For example, participants indicated that the SDGs are introduced in primary and secondary schools, so that engineering students enter the university already aware of the SDGs. This awareness, in turn, has an effect on the interests of incoming students in working towards the SDGs. For example, one faculty participants indicated that because of students' exposure to the SDGs in school, discussing the connection between the SDGs in an engineering class did not excite students as much as actually working on an engineering project that addressed an SDG:

> The challenges often I see when introducing for project modules, or introducing them to these sustainability goals is it's hard to, you know. They kind of take it for granted. They kind of take it at a surface level without looking at these sub-goals. (D-F02, Pos. 70)

> So they really care about the projects. And when the sustainability goals are inter-linked with the projects, they also care about these goals a bit. (D-F02, Pos. 80)

Since students are aware of the SDGs prior to starting their engineering degrees through their primary school education, they wanted to contextual their course projects around the SDGs, and faculty responded to that desire in the ways they structured their projects. Overall, participants discussed on how government policies informed culture norms through the introduction of SDGs in school, the research funding and projects, and in turn in the education opportunities faculty created for students at LP-D.

4.2.1.2. Industry Engagement

Industry engagement emerged as a salient influence across all participants. This included industry partnerships, internship, and employment opportunities for students when they complete their education, and industry expectations of what engineering graduates should be capable of. LP-D has strategic collaborations between industry and international partners to work towards sustainability. According to the website, "At [LP-D] we are in a special position when it comes to helping society solve its specific problems. Working with partners outside the university is a natural thing for both [LP-D] researchers and [LP-D] students — and it has been since the very first years of our history" (D-W06). In addition, participants discussed the industry focus on green technology and renewable energy in Denmark and how students working on projects that incorporate sustainability would be beneficial to them when they enter the job market, as illustrated by the following excerpts:

> I think because there is focus on it in general and in Denmark, it is helpful. And right now, we have a lot of them-- there are a lot of jobs for students. And I think, for example, right now we're building renewable energy projects that are everywhere, so a lot of students-- as long as that sort of focus is there, then there's a need for them. And everyone has sustainability built into those plans and their strategies. And they have to if they want these jobs. (D-F05, Pos. 4)

> So the companies themselves, they want to be drivers of green technology. Of creating positive impact. And I think in some might be branding. The other is a new business model. That's my understanding. […] But it's actually creating indicators that show that driven internally force being done. So I think there's a mind – some switch here in that perspective. So this will come naturally to the locations. Because there's a close collaboration in that sense. (D-F04, Pos. 24)

Participants also spoke about how incorporating sustainability in the projects and courses during their engineering degree program encourages a sustainability mindset that in itself is appreciated and valued by the industry, as in the following comments:

> If students have ideas and have an understanding on how can we build-- how can we add sustainability dimension to everything that we do because that's the

> only way that the companies can move in this direction. That's by hiring young people who come with mindsets of doing this. There's no specific effect of writing a white paper, a policy for a company, if it's not embedded within the employees of the company. And so that's something that we strongly feel that we have to deliver, so the skill sets for adding it to the value chain of the companies that hire our young people. (D-K02, Pos. 4)

> I think it helps them be familiar with problems of the same nature. So a lot of companies here in [city in Denmark] at least are also addressing what goals they are working on right now, and what projects they are doing. With what goals right now. And when they are familiar with these topics, they might see themselves more prepared. Because they've done similarly. And they know what they are talking about when they are talking about the specific goals. So it kind of prepares them. It also has this mentality of making a difference And kind of helping society or the world around them. Which is in the interest of most companies as well. So I think it helps them be prepared, and helps them have an appropriate mindset. Which it makes it easier to transition into the workforce. (D-F02, Pos. 129)

As these comments suggest, faculty see integrating the SDGs into courses as a way to increases students' preparation for engineering work.

Interestingly, faculty participants also discussed the challenges of incorporating the SDGs and sustainability in their courses while trying to complete the syllabus and ensure the standard technical knowledge and competencies in the typically five-year engineering programs. "Too much [to cover], too little time," one faculty said. Another, when asked about how the industry appreciates the incorporation of sustainability, mentioned that while sustainability is an important mindset that is required in engineering, a technical foundation is more essential. Participants indicated that while the industry demands and values the incorporation of SD in education, especially the sustainability mindset in engineering graduates, it is not at the cost of existing curriculum standards:

> Yes, [sustainability is appreciated] but [companies] also say we should not put too much emphasis on it. Because they said it will be unnatural. Because they already, whatever they do, they think sustainability into what they are doing. So it's not something that we should say that all our courses are sustainable biology, sustainable chemistry and sustainable engineering. Because they say

> that'll be too much. They already know that they cannot do anything if they don't think sustainability into it in some way. Then there are certain skills that they would like our students to do. For example, life cycles analysis, carbon footprints calculations, water footprint calculations. Where we could probably do more. But, but again if we then say, "OK we can add these. What should we take out?" Then they'd typically say, "Better keep it as it is." (D-F01, Pos. 193)

Notably, as this comment suggests, the concern about spending too much time on the SDGs is not because industry does not value them, but rather, because awareness of and attention to is already so pervasive in the culture and an accepted component of engineering work. Such comments suggest that at the university level, students do not need to be taught about the SDGs, but rather, develop the technical skills need to implement them.

4.2.1.3. Funding Agencies

Influenced by both public government policies as well as private industry partnerships, external funding agencies played a role in LP-D faculty decisions to engage in EESD. Government policies, such as the Danish Climate Law, which has specific goals of reducing gas emissions, influenced the institutional mission and culture as well as internal funding and reward structures, and in discussing EESD, faculty at LP-D often contextualized their teaching by talking about this broader landscape of research funding. One participant explained:

> One place where I actually do think sustainability and sustainability goals means quite a bit is in our, you could say, sort of, strategic behavior. Where should we put our focus, for example, in order to extract external funding? And there, I think, people look very much on what do funding agencies, for example, describe about sustainability, sustainability goal? Because lot of the funding scenario actually do somehow follow some of these sustainability goals. (D-F01, Pos. 118)

Not only did funding agencies include Denmark's public and private organizations, but it included European initiatives: as another participant explained:

> Now the European framework for research is based on [the SDGs]. Europe is about missions. I have Mission 1, Mission 2, Mission 3. You have the green

> transition funding. So the funding is actually in that direction, as well. (D-F04, Pos. 123)

Several participants talked directly about the links between the influence of funding on the institutional strategy and research directions and its influence on course content and teaching. As one participant explained:

> When we talk about courses, well, a lot of the courses are linked to research. I mean there are certain basic courses where – the basic stuff. But we try to keep updating the content of the course. So let's say it follows electric cars right now. What kind of electric drive you have in a car. So even if the course has been there, and has presented – and the title of the course was Control of Converters for Electric Drives. An electric drive could be an elevator, how it's called, a band. All these – you have a huge [electric conveyor belt]. Where in electric car you have more complicated systems, so. The core content of the course might be the same, because we're talking about electric motors, power converters. But the application is updated to match nowadays research. And that's also nice, because then we involve all of our researchers. They can give examples, and then the researchers can also teach. (D-F03, Pos. 191)

The link between research and teaching is reflected in the kinds of courses added to the curriculum as well as the examples faculty use in their courses while teaching core concepts. Thus, the funding for sustainability initiatives encourages not only the research by the teaching practices as well.

4.2.1.4. Cultural Norms

Most broadly, apart from the concrete influences discussed in the previous sections, the awareness of the SDGs and an unprecedented level of concern and commitment towards sustainability was seen as a cultural force or a norm that was seen in Denmark, especially in the current generation of youth. This growing dedication is linked to the introduction of SDGs at the school-level school level as well as a palpable "sense of doom" in the younger generations of both students and faculty as they recognize the urgent need for action. One of the participants

elaborated on how students bring in a sense of urgency and responsibility toward a sustainable future:

> There is an awareness. There is a sense of doom in the younger generations. And the young generations, they have power. We might not want to recognize it, but they have power. They are young now, they will be older tomorrow. And they will be in charge. And there's a danger in this. If they have a sense of doom, and at the same time they don't have a sense of where they can be led, how can, you know. They feel that we are responsible for something that they need to solve. The sense of being compelled to do something that is not their own responsibility, or they were not the causes for it is also quite strong. So that is a force [pushing faculty to engage in EESD]. (D-F04, Pos. 98)

This cultural norm was also seen among younger faculty, who like the students, are concerned about the generations to come:

> You have staff that sees [the incorporation of SDGs] as an opportunity. And the younger the staff, the more they see it. Because the younger staff also see it closely to their life, in the sense that, "I want to have a family. I have that question. I'm going to have a child," or, "I want to make a family. In which kind of world I'm putting my children in," you see? (D-F04, Pos. 74)

Notably, as this excerpt indicates, this perception emerged in the interviews as widespread ("the staff"), suggesting that while it is an individual belief in some sense, its pervasiveness makes it more of a norm that everyone is aware of.

Acknowledging this culture among the youth, one of the participants addressed that while it influenced engineering education, the ability to quantify the benefit and harm is difficult and raised concerns suggesting that the cultural norm might be more emotional than factual:

> I think in society, there's been much more emphasis in sustainability. At least in some areas. And lot of focus on climate these days. Climate change is problem more about that. And also, a lot of this is much more based on feelings than actually knowledge. […] I think many people are trying to do something and now they – in order to, for example, have a lower carbon footprint. But very few actually can tell you if this really matters anything. OK, I have one day a week where I don't eat meat. What does that matter? No one will I think. Then people think they've done something good. And then, but they can't really quantify what amounts. And so they say "Ah now I need a reward. So I go out and buy an extra t-shirt." And do you then know what is

> good and what is bad? So I think a lot of these things are still based on feelings. I think there's actually a tendency in this country to believe that we as a country can solve the climate crisis. If we cut CO_2 emissions. Forget that that also coming, CO_2, from other sources. And I think there's too little emphasis on how complex it is, actually. […] (D-F01, Pos. 118)

To that end, the participant expressed that the need to be able to base decisions on logical arguments was an important skill as students of science and engineering:

> I mean for our university, I think we should work on basic understanding, basic knowledge. And also development of new solutions. So that's the engineering part. And I think this is by far the most – at least for the natural sciences and the engineering departments at universities. Then I think all the schools or educational centers actually also have an emphasis on letting their students understand that they need to do more based on knowledge. And less on feelings. (D-F01, Pos. 118-138)

While the participant attributed emotions or "feelings" to the sense of doom in society, the faculty expressed a responsibility on educational institutions to address the complexity of SD using scientific reasoning. It can thus be noted this external influence of the cultural perspectives of SD was reflected in students and faculty to engage in EESD.

4.2.2. Internal Influences

Several internal influences, or factors that originate within the institution emerged from the interviews. At LP-D, the salient internal influences that affected faculty choices to engage in EESD were the institutional mission, the institutional culture and reward structures, and pedagogical approach, which are defined in Table 4-3.

Internal Influence	**Definition**
Institutional mission	Institutional mission, vision and culture
Institutional culture	Internal environment and rewards related to faculty recognition and promotion
Pedagogical approach	Teaching and learning practices adopted within the institution

Table 4-3 Definitions of internal influences at LP-D

These influences were informed by the faculty, key informants, university websites, and observations. The salience of each of these influences is shown in Table 4-4.

	Institutional mission	Institutional Culture	Pedagogical Approach
F1	X	X	
F2	X		X
F3	X		X
F4	X	X	
F5	X	X	X
KI	X	X	X

Table 4-4 Salience of internal influences across participants at LP-D

4.2.2.1. Institutional Mission

The institutional mission at LP-D played a significant role in the decisions made by faculty at LP-D. Two aspects of the LP-D mission and strategy were specifically mentioned in the interviews: mission-oriented university and sustainability efforts.

Mission-oriented University

According to the university website, LP-D positions itself as a mission-oriented university indicating that the institute is "guided by a meaningful purpose that goes beyond [their] own organization and contributes to the sustainable development of the world." The mission-oriented concept is based on a framework designed by the economist and advisor to the European Commission, Mariana Mazzucato. The framework, as shown in Figure 4-2, provides a clear strategy of the institutions' goals and desired outputs. It also influences the organizational culture and approach to meeting the goals.

Figure 4-2 Mission-oriented strategy (D-W01)

The faculty and key informants at LP-D referred to this strategy in reference to how the institutional culture influenced their EESD work, as in the following examples:

> So on a very surface level, we have posters, and we have some ornaments with the sustainability goals on it, so that we are kind of forced to see them every day we go to lunch, and every day we have a meeting, [laughs] you know? But we also are a mission-oriented university, which means that we have research groups which are divided all into some different missions. And these missions have very defined sustainability goals. (D-F02, Pos. 106)

> And the overarching vision is that by 2026, [LP-D] wishes to be recognized as a mission-driven university that contributes to sustainable development of the world. So that's what we want to accomplish with our education and our research. (D-K02, Pos. 4)

Aligned with the sustainable development goals, the mission-oriented university strategy was an important aspect of the institutional culture; that is, while we often dismiss the idea of "mission" as something superficial or "just talk," at LP-D, this mission-driven strategy was evident both visually around the university and verbally in the interviews with participants. As a result, it appeared to directly support widespread engagement in EESD given the focus on societal

relevance and cross-disciplinary work. This strategy is also aligned with the funding opportunities as well as the national priorities and industry partnerships:

> The largest public funding organization, Innovation Fund Denmark, has allocated a very high proportion of their funding to what they call the inner missions, which are for specific themes where they support mission-driven research. And the private foundations are increasingly working based on strategic plans where they have mission-inspired themes as their guiding principles. (D-K02, Pos. 4)

The institution's mission-driven strategy fits well with the public and private organizations that it interacts with, and directly encourages faculty engagement in EESD.

Focus on Sustainability

As indicated in the institutional mission and strategy, LP-D's mission focuses on addressing societal problems, and that in turn leads to a heavy emphasis on sustainability. This is very apparent in the institutional culture, as captured in the observations, as well as university websites. With student projects shaped to align with the SDGs and research-driven toward sustainability, there is an undeniable focus at LP-D on sustainability initiatives. It is indicated in the institutional environment, where the SDGs are visually displayed throughout the campus, as seen in Figure 4-3.

Figure 4-3 SDGs displayed in the faculty break room

It is also evident in student project showcases, as seen on the university websites. In addition, LP-D's research initiatives are explicitly aligned with specific SDGs. The university displays infographics on how the research at LP-D aligns with the SDGs. These figures include bar graphs that show the number of publications and projects that address each individual SDG, and line graphs that indicate the number of publications focused on the SDGs each year (D-W04). According to these figures, most efforts have been on SDG11, 7 and 12 (Sustainable Cities and Communities, Affordable and Clean Energy, Responsible Consumption and Production, respectively).

Several faculty and key informants indicated that LP-D was founded in close alignment with the needs of Denmark's society, and those needs in turn drive this focus on sustainability. They emphasized the deeply rooted nature of a problem-based curriculum model within the educational and research framework of LP-D and how the historical context of the country and institution has shaped the institution's mission and goals towards sustainability. When asked why LP-D has a strong emphasis and focus on sustainability in its mission, one of the key informants explained how LP-D played a pivotal role in the economic revitalization of the local region in Denmark and how the growth of high-tech industries and innovation has become deeply embedded in the identity of the institution:

> This is our DNA. [LP-D] started in [year] with this problem and project-based curriculum model. So that has been an integral part of our education always. But it has also always inspired our research. So our research also implicitly has been problem-based. […] In the 1960s, this region was experiencing a very difficult time. [City in Denmark] used to be a traditional industrial city with lots of factories, traditional industry, a lot of blue-collar work, blue-collar labor. But then, one by one, these large companies, the shipyard, the construction companies, they disappeared for various reasons. So they thought it was a local depression with a lot of unemployment and so on. And then visionary people created this idea of maybe we can have a rebirth of the region as a high-tech region if we could get a university. And fast forward to many

> years later, this is pretty much what happened, that a university came. And the region of northern Denmark has pretty much been in the top 10% as a growth region in Europe. And if you look at the profile of that, it's exactly that. It's high-tech. It's innovation. It's derived from what comes from university in terms of our graduates and in terms of our researchers who collaborate with local companies. So it's really a part of our DNA that we are here for a reason. And so it's part of [LP-D] that whatever we do, we try to bring in partners. Now we are not a local university anymore. We are international university. So we work with local, national, international partners. But we have never forgotten where we—It's been really part of our DNA of our culture that we're here for a reason. And so the choice of this mission-driven strategy is not random. It's a natural evolution of where we've been coming from. So we want to be recognized academically as leading scholars in the areas where we find ourselves. (D-K02, Pos. 4)

According to the informant, LP-D emerged out of a need to address the social and economic development of the local region in Denmark and has since worked in partnerships with industry to continue its growth. While LP-D today has expanded its collaborations beyond the local level and become an international university, it recognizes its roots and the original mission. The institution maintains a strong commitment to partnering with stakeholders at the local, national, and international levels. The choice to adopt a mission-driven strategy with a focus on sustainability is not arbitrary but a natural evolution aligned with the institution's historical trajectory and cultural heritage. Another faculty, who was also an alumni of LP-D reinforced the institution's vision and its strong culture:

> I think it goes back, and maybe all the way back to when [LP-D] was founded. And that sounds like it's going to be a very long story. [laughter] But it was founded in the '70s, and it was sort of—we had the big old universities in Copenhagen. And then [LP-D] was sort of this slightly a bit more hippie grassroots thing that came in the '70s. And I think somehow it dates back. That was really big part of those people who started in the beginning. They were really front-runners, I think. And then thinking about sustainability even if it was before popular. But I think it goes back. I'm not sure it goes way back, but at least way back before my time. So the people who taught me and who had been in the department for a long time they've sort of started this. I think it was with that focus, yeah. (D-F05, Pos. 4)

The clear institutional priorities towards the SDGs and a holistic approach to education is also reflected in program and course design. It creates opportunities for faculty to incorporate SDGs into their courses and research in a more structured way. This link is further seen in how faculty see their reward structures and departmental culture.

4.2.2.2. Institutional Culture

The institutional culture at LP-D, which was a reflection of the institutional mission had an influence on faculty engagement in EESD in two ways: rewards for SD research and academic freedom. As an extension of the influence funding agencies had on faculty decisions, faculty received internal rewards for aligning research to the SDGs influenced how faculty incorporated the SDGs. For example, when asked about the incentives that faculty have for aligning themselves with the university goals towards the SDGs, one of the participants explained the following:

> I think there are indirect benefits. Because I think if you sort of align yourself, your own research, your own teaching with university strategy, your options of gaining support will be better. And it's clear in a – we do many wet experiments in the laboratory. These are expensive. And we cannot do what we are doing if we had only the funding from the university. (D-F01, Pos. 169)

Since external funding structures were aligned with the SDG, applying for research grants that explicitly target the SDGs were strategic for faculty promotion and career growth. To that end, the institution encouraged these research efforts by offering internal funding. These internal funds incentivized faculty to align themselves with the university strategy so that they could purchase the expensive equipment required to conduct the research. This internal funding structure also provided the needed support for initial efforts toward interdepartmental collaboration, which as the participant mentioned, is needed when addressing sustainability. This

initial investment from the institution provides the initial support that could eventually lead to external funding:

> And there are some things at the university where you can actually apply for small amounts of money to do collaborations with people from other departments and do something interdisciplinary. And basically the main issue there is that this work should lead into applications. So you have better chances for obtaining external funding. And that of course would be rewarding. (D-F01, Pos. 104)

As an outcome of SD-related research, faculty were able to bring their research experiences to their teaching role:

> When we talk about courses, well, a lot of the courses are linked to research. I mean there are certain basic courses where – the basic stuff. […] The core content of the course might be the same. […] But the application is updated to match nowadays research. And that's also nice, because then we involve all of our researchers. They can give examples, and then the researchers can also teach. (D-F03, Pos. 191)

As the faculty noted, engaging in research directly aligned with SD, faculty used current research areas to update their courses with relevant examples. Thus, the internal rewards for research indirectly affected EESD teaching choices.

It is important to note that while there were rewards in the form of internal funding for research engagement, there were no explicit rewards for integrating the SDGs in their teaching. As one of the participants pointed out, because most faculty at LP-D engaged in EESD, there was nothing extraordinary about it that merited specific rewards:

> I don't know if it specifically is rewarded. It's not, I mean, whether I focus more or less on sustainability, I don't think sort of the department thinks much about it because we all do it. (D-F05, Pos. 5)

Participants also indicated that there were no specific rewards for incorporating sustainability in teaching. As one participant indicated:

> I mean you can have the dean clapping your shoulder, saying you're doing a good job, but that's about it." (D-F01, Pos. 108)

But even without explicit rewards, discussing sustainability throughout the curriculum was treated as a cultural norm. Notably, while there were no specific incentives for the integration of sustainability in engineering education, there were incentives for working toward SD and including the SDGs in the research activities, which in turn indirectly influenced teaching given the links between teaching and research noted earlier.

Another aspect of the institutional culture participants cited as supporting EESD was the academic freedom in their research and teaching activities. The freedom to incorporate topics and teach in a way that the faculty wanted was well-appreciated among the participants. This was especially relevant for faculty at LP-D, where there is a strong focus on sustainability. Faculty at LP-D had the freedom to engage in EESD in a way that made sense to them. One participant explained how the push for sustainability and SDGs at LP-D doesn't necessarily mean that all courses integrate the SDGs:

> There're some courses I don't talk about sustainability goals at all. And I think there are lecturers which have courses which do not really – or it would be too much of a detour to start talking about sustainability goals. And I think trying to force everybody to talk about sustainability goals is maybe a small waste of time. It should be included where it can support the education. And not – so I think that for some teachers, and for some – it makes a lot of sense. And for others it doesn't. And that would also reflect on their, you know, how they see. But I don't think there's anyone here, researcher or teacher, that thinks that – or [laughs] directly opposes the sustainability goals. It's just we need to talk about them in the context that makes sense. (D-F02, Pos. 116-117)

The institutional culture at LP-D allowed faculty to exercise their freedom in teaching and incorporate the SDGs where they found it fit. While there were no explicit rewards for engaging in EESD, participants indicated that there were internal rewards for aligning their research to the SDGs, which in turn, influenced the teaching as well. Moreover, the commitment to PBL created

an overall institutional culture at LP-D that enabled the seamless integration of the SDGs in engineering courses.

4.2.2.3. Pedagogical Approach

As indicated in the contextual site description, LP-D is well-recognized for its PBL approach. This pedagogical approach, which was embedded consistently across all the programs offered at LP-D, appeared as a translation of LP-D's mission and vision. As the literature indicates, PBL is very conducive to the integration of SDGs in courses, and for faculty, it was a seamless part of their work.

This PBL model provided students with the opportunity to develop their technical knowledge, teamwork skills, and work "with complex and global issues e.g., connected to the Sustainable Development Goals (SDG)" (D-W05). Observations and photographs captured from around the institution's campus also indicated student projects were specifically aligned with the SDGs. On the student project posters that were displayed around campus, there was an explicit link to how the projects addressed the SDGS. The faculty participants, too, described the link, noting that problems are intentionally aligned with the SDGs:

> Our missions are first. To solve problems where there are issues in society and industry from a problem-oriented view. And then we second find the sustainability goals which match and help us shape the project. (D-F02, Pos. 107-108)

The PBL approach at LP-D not only enables students to develop specific SDG-related technical skills, but also helps them cultivate a sustainability mindset and related critical thinking skills. Thus, while explaining how the SDGs define the problems that the engineering students at LP-D work on, one participant explained:

> So here we are spending half of the students' workload on a project. And I would say a good project in the early semesters starts from the sustainability goals, and also ends in the sustainability goals. And what I mean by that is in

> the start, it helps to bring relevancy to the problem they are trying to solve. They are always trying to solve some initiating problem. (D-F02, Pos. 39)

The PBL approach is a key part of the institution's mission and vision and lends itself to integrating the SDGs as part of the holistic development of the engineering students. This approach also played a role in faculty decisions to engage in EESD. For example, in the Department of Energy, certain PBL courses, especially during the early semesters of the program, were designed in a way that a specific SDG provided the context for the problems students could address in their projects. To guide these projects, the faculty who were not the main course instructors were assigned as supervisors for the projects:

> And then, often in that process, when [students] submit a project proposal for a semester, often you also have an idea of what supervisor you recommend for this project. And then if that project is chosen, we go and ask the supervisor, "Are you still up for doing this teaching task?" And then it's kind of figured out on a project-by-project basis. I think that's the best way of describing it. (D-F02, 55)

The supervisors were not assigned at the beginning of the course but were selected based on their research interests and expertise. The supervisors are, at that point, given the choice to guide the student projects. Here, the faculty's decision to engage in projects related to a specific SDG was influenced by the department and individual faculty's expertise and interest in the specific project.

4.2.3. Individual Influences

At the individual level, experiences prior to joining LP-D, teaching beliefs, and beliefs of SD and engineering were salient influences among the participants. Because of the strong external and internal influences in faculty decision to engage in EESD, the salient individual influences were in alignment with the other levels of influences. Table 4-5 provides definitions for each of these influences.

Individual Influence	Definition
Beliefs of SD and Engineering	Beliefs about SD, engineering and the relationship between the two
Beliefs about goals and values of education	Beliefs about the role and responsibility of an educator

Table 4-5 Definitions of individual influences at LP-D

The individual influences were identified predominantly using faculty interviews. The presence of each of these influences in the faculty interviews is shown in Table 4-6.

	Beliefs of SD and Engineering	Beliefs about goals and values of education
F1	X	
F2	X	X
F3	X	
F4	X	X
F5	X	X

Table 4-6 Salience of internal influences across participants at LP-D

4.2.3.1. Beliefs of the Relationship between Sustainable Development and Engineering

All the participants valued the importance and acknowledged complexity of addressing SD through engineering. They found the SDGs useful as a framework to quantify the abstract goal of SD. The faculty explained that as engineers offer solutions to societal challenges, it is important that they see the big picture. One participant said:

> I think that all engineering should strive for sustainable development. I don't know if that's an answer, but I think it should be relevant for every engineer to know and to keep that in mind because whatever we do-- we develop things that are going out into practice and a lot of it has a huge impact. (D-F05, Pos. 4)

Participants also recognized the conflict engineers face defining and quantifying sustainable development and appreciated how the SDGs provided a framework to define SD and explicitly define specific goals to work towards:

> If sustainable development was an equation, the problem was solved many, many years ago. (D-F04, Pos. 85)

> We are engineers, we like not to have so many opinions on things, right? The sustainability goals are a set of goals, I think it's a good concept to make something concrete when we want to – generally speaking, countries want to do a lot of things. We have a lot of things we want to change, and a lot of places we want to go. So I think it's – From my point of view, I think it's a good thing to make it concrete, and kind of to vectorize our direction, right? Where do we want to go? This helps tremendously in that regards. So to find the high-level goals and, you know, how we can promote this sustainable living in the future. (D-F02, Pos. 29-30)

The participants expressed the struggles engineers face in working with an abstract goal such as sustainable development, which is difficult to measure and quantify, but also saw the relationship between SD and engineering as an undeniable one that had to be addressed. The SDG framework was thus seen as a useful tool to include in engineering education because of the concrete nature of the goals and related indicators that help quantify the more abstract goal of sustainable development.

4.2.3.2. Beliefs about Goals and Values of Education

Belief about what faculty wanted for their students was also a salient influence in their EESD decisions. That is, participants often framed EESD in terms of particular kinds of student outcomes that they valued. These factors influenced how they wanted to incorporate the SDGs and what they wanted students to leave with from the integration.

Some faculty wanted students to develop a sustainability mindset:

> So I don't see sustainability as a competence, per se. I see sustainability as need to be present. Maybe should be sustainability mindset. Like we have engineering mindset, like we have entrepreneurial mindset. Maybe it's that that we need. And then we need to link that sustainability view into their disciplinary. (D-F04, Pos. 14)

Others focused on contextualizing engineering problems and solutions within the big picture:

> I don't like to teach sustainability goals just by themselves. […] But what I like to do is only talk about the sustainability goals in the context that is relevant to the project. So we are talking not about sustainability goals, we are talking

> about what is the interaction between the sustainability goals and the project. (D-F02, Pos. 78)

Another explained how their role in educating engineers to work towards SD was also a reflection of their effort towards SD:

> And sometimes I even think that that's sort of one thing that I contribute to sustainable development. Me and my research that teach young people that are educated-- like they're going out, straight out there. So if I educate them well, then they're like my biggest impact on sustainability. I think that's motivating. (D-F05, Pos. 4)

As these comments suggest, EESD was closely linked to their beliefs about the goals of engineering education more broadly, and envisioned students' holistic development that would enable them to serve society positively.

4.2.4. Alignment and Interactions between Influences

As the influences were identified during the analysis, the interactions between the influences also emerged. Connections emerged among external influences, between external and internal influences, among internal influences, between internal and individual influences, and among individual influences, as seen in Figure 4-1, shown here again for convenience.

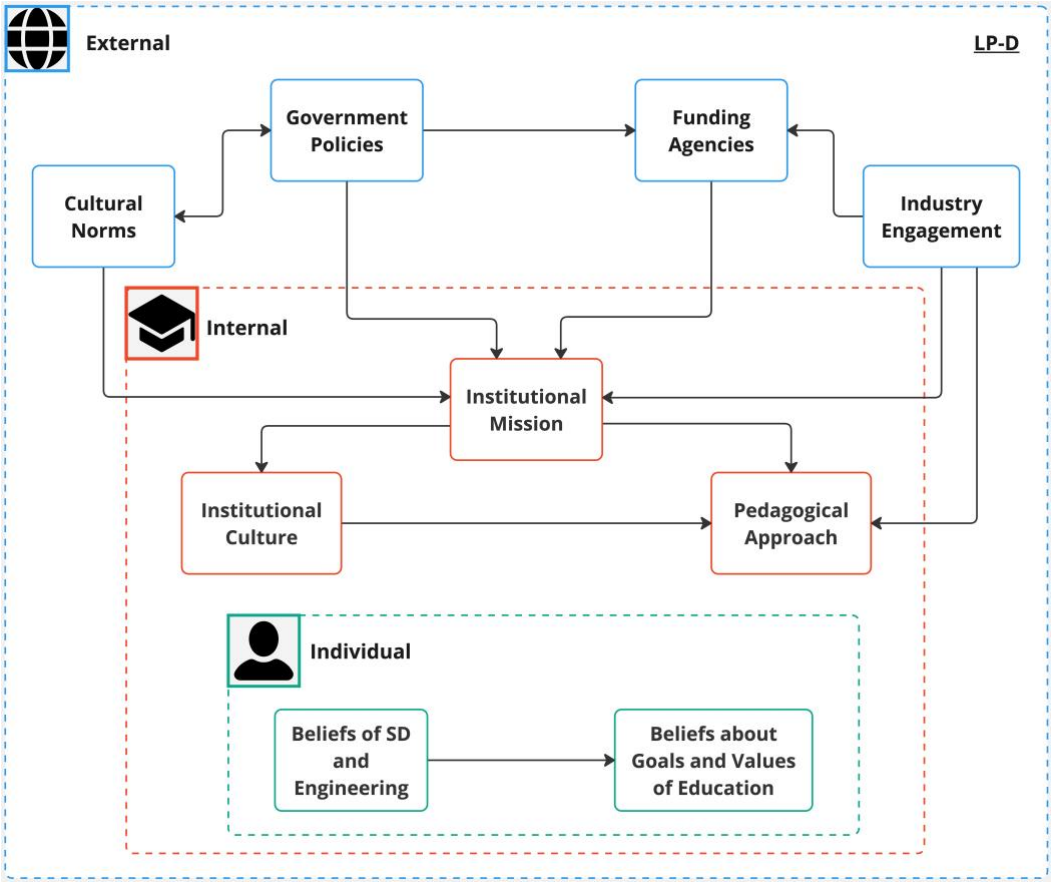

Figure 4-4 Summary of salient influences at LP-D

The interview data revealed direct interactions between the influences, captured by the arrows in Figure 4-4. For example, the figure shows the link between government policies and funding agencies captured in several of the excerpts in this section. At the same time, the data also revealed more subtle connections or alignment, indicated by the dotted lines in which one layer is enclosed by another, such as the link between external and individual influences implied as faculty expressed how integrating sustainability was part of their cultural identity or DNA.

At LP-D, there was both direct interactions as well as implicit alignment between the external and internal influences that supported faculty decisions to incorporate the SDGs in their teaching. Given the national priorities, cultural norms and the historic context of LP-D, the data highlights the ways in which internal influences such as the institutional mission were heavily shaped by external ones. The PBL approach to programs and courses offered at LP-D were also

an example of how industry engagement played a direct role in situating the SDGs within engineering projects broadly. In addition to these direct influences that participants explicitly discussed, the data also indicated the ways the culture of the institution was aligned with national priorities, though such connections were typically more indirect, implied by the ways participants talked about alignment between what the institution does and what the nation wants or needs. For instance, government policies directly influenced funding agencies to focus on sustainability, which in turn, shaped institutional priorities. Since the institutional culture and reward structures of internal funding supported faculty to pursue research that addressed the SDGs and sustainability, there was an indirect connection, or an alignment between the external and internal influences.

The alignment of individual influences with both the internal and external influences was evident, although direct connections were less visible in the data. Participants identified with their department, institution and the European context, and there were references to how the environment they were exposed to or their academic background influenced their general beliefs about teaching, sustainable development and the role of engineering. However, there was not enough data to explicitly link any of the external and internal influences with the individual influences.

4.3. Findings at LP-US

At LP-US, while external and internal influences were present, faculty integration of the SD was predominantly shaped by individual influences such as beliefs and prior experiences. Initiatives to practice EESD operated at an individual level, with significant variation in practice depending on institutional support, time, and resources. While these individual faculty initiatives led to some faculty collaborations and groups focused on incorporating the SDGs, there was

limited support and no recognition for doing so. At an institutional level, there was an implicit alignment between the university mission and the SDGs given the land-grant status of the institution, but the alignment was not pervasive either visually around campus or in the interviews. Other than a few programs and courses that explicitly addressed sustainability, most initiatives to incorporate the SDGs in the engineering curriculum were driven by individual interested faculty, and thus, were inconsistent and localized efforts. While external influences such as external evaluation systems and globalization have affected internal factors such as institutional goals and missions, these influences appeared relatively new and limited in their impact. Figure 4-5 summarizes the salient influences and the interactions between the influences.

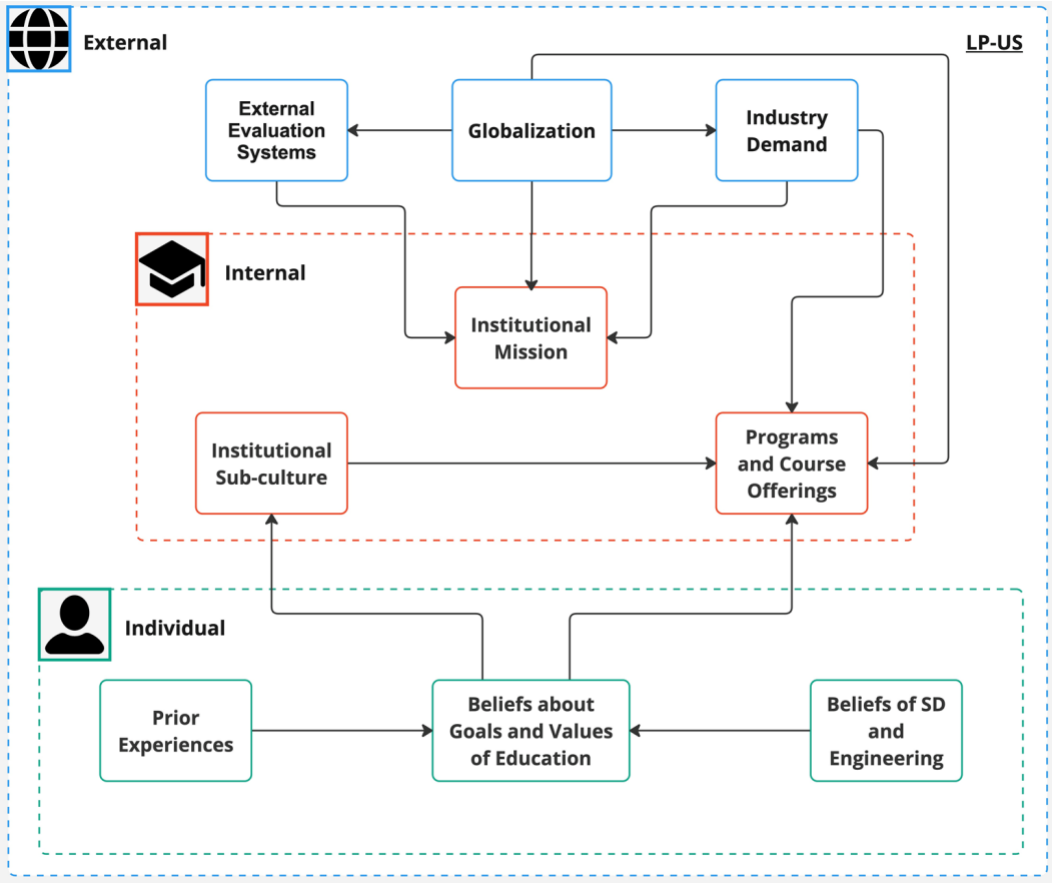

Figure 4-5 Summary of salient influences at LP-US

4.3.1. External Influences

Three external influences on the incorporation of SDGs in engineering education emerged from the faculty and key informant interviews: industry demands, evaluation systems, and globalization, which are defined in Table 4-7.

External Influence	Definition
Industry Demand	Industry demands and employability expectations
Evaluation Systems	External evaluation systems such as accreditation boards or ranking systems
Globalization	Interaction and integration among people, companies, and governments worldwide

Table 4-7 Definitions of external influences at LP-US

The presence of each of these influences in the faculty and key interviews is shown in Table 4-8.

	Industry Demand	Evaluation Systems	Globalization
F1	X		X
F2	X	X	X
F3	X		X
F4	X	X	X
F5	X	X	X
F6	X		X
F7			X
KI	X	X	X

Table 4-8 Salience of external influences across participants at LP-D

4.3.1.1. Industry Demand

Faculty at LP-US in part linked their own engagement in EESD to the ways the engineering industry addresses sustainability today and believed that graduating students who have the skills and mindset that align with that focus would have an advantage. As one explained,

> There aren't very many engineering jobs that don't think that this is important at some level. So if they're competing against other-- if you've got a handful of mechanical engineering students and one of them has the [program name] minor, they can very clearly say, "I have a sense of how environmental impacts influence my technology or my discipline, and I have some skills that I can apply." So I think they're-- all the time, I hear students say, "Yeah, I talked about this green engineering thing and it helped me get the job because the

> company--" and not every company cares, but even the companies that aren't doing green engineering can't avoid the fact that it's in the news. The regulations are coming. Consumers care about it, whether they want to do it or not. So I think the students have an actual advantage. It's just like if you have a business minor or a math minor. You can point to actual skills that most companies see the direct impact of them and say, "Yeah, that student is better," or more prepared, at least. (US-F04, Pos. 4)

Given the demand and expectations for such skills, LP-US does offer a small number of sustainability-focused minors and certificates, and as the excerpt above suggests, faculty saw those as opportunities for students to stand out from the crowd during their job searches and have a better chance of employability and more job opportunities, especially those aligned with sustainability. The importance of industry demand was also evident as participants talked about alumni from such programs, as in the following comment:

> I brought in alumni from [LP-US] into the classroom to talk and educate what they're doing out in the real world. And one of them is in the solar industry. One of them worked for Target in the [environmental, social and governance] (ESG) space. And they both talked about the [program name] program and how that helped them as they moved through and brought them to where they are today. (US-F06, Pos. 4)

Participants also noted newer additions to LP-US that were emerging as a result of this industry demand. One of the key informants mentioned a new sustainability-focused experiential learning program designed to “engage more students in hands-on learning opportunities around sustainability” (US-W07; US-W08). The program was not part of any specific curriculum but was an optional learning opportunity that allow students to connect with faculty who are working on “climate action commitment.” As the participant explained,

> So for our climate policy specifically, we're trying to build something called the [program name]. And what that's really trying to do is integrate the infrastructure and facilities and operations staff with the academic stuff because we're currently underutilizing our faculty expertise, grad student projects that can be really ambitious and helpful for the campus, the cutting-edge research that we do, and also the idea that we want to get students hands-on experience with all these energy systems and environmental systems because that's where a lot of lucrative jobs are. (US-K03, Pos. 4)

This industry demand not only influenced specific programs offered at LP-US but was also key in why participants chose to integrate the SDGs into their engineering courses; as one participant explained:

> I think more people and more clients recognize that we can't just keep building and doing things the same way that we've always been doing it. And that the world is changing more quickly, resources, how we spend these resources. Like delivering value to these – to clients. There's better ways to think through it. And sustainable design or using principles of sustainability gives us a lens to help deliver projects that are better for them, and help us stand out in the industry. So, and making that pitch to client – and clients are asking for this more and more. And so I think for understanding these things coming out of school gives them a leg up on their peers who don't. (US-F02, Pos. 111-112)

As a whole, industry demand was a salient influence on faculty decisions to incorporate the SDGs at both the program level and at the course level outside those programs.

4.3.1.2. External Evaluation Systems

A second factor linked to participants' engagement in EESD was external evaluation, including ABET accreditation and university ranking systems (e.g., *U.S News & World Report* and the *Times Higher Education* ranking). ABET is a non-profit, non-governmental agency that "accredits programs in applied and natural science, computing, engineering and engineering technology" (ABET, n.d.). These accreditations provide quality assurance to ensure that graduates are prepared for a specific profession. Most of the engineering programs at LP-US have been ABET accredited or will seek accreditation. And as Figure 4-6 illustrates, sustainability and the SDGs are highlighted by ABET.

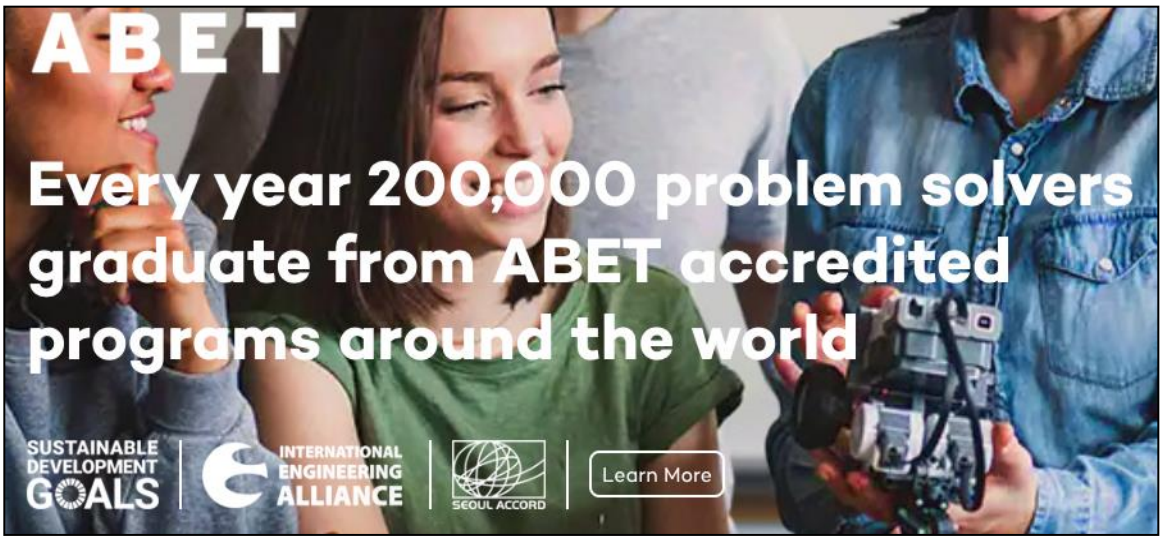

Figure 4-6 Alignment between ABET and the SDGs

Participants also referred to the ABET criteria while discussing why it was useful to incorporate the SDGs in their courses:

> I mean, it definitely ties when you look at ABET criteria. I'd have to look specifically at the one that's more oriented toward social-- you're familiar with PESTLE, probably? There's one kind of with a few of those constructs, like social-economic considerations. And so engineering doesn't happen in a vacuum, right? So it's important to understand that everything has a context, and developing ethical reasoning, thinking skills, and understanding that within a context with the constraints you have and things like that. (US-F05, Pos. 4)

Another evaluation system that relates to the SDGs is the Times Higher Education Impact Ranking which "assess universities against the United Nations' Sustainable Development Goals (SDGs)" (Times Higher Education, 2021). While this ranking has influenced LP-US to be more explicit about the integration of SDGs in the university, one of the faculty expressed their concern about how this evaluation system has shifted a focus towards the SDGs in the institution, it is not properly reflected in the institution's environment or culture:

> But I know and you may know that there's this one global ranking that the university is now a little bit more focused on that has SDGs in it. And apparently [LP-US] is kind of moving up on that scale. But it doesn't feel like the-- I don't know. I'm a little skeptical of how that ranking is done, because when I look around campus, I only see really a handful of people addressing this seriously. (US-F04, Pos. 4)

These external evaluation systems have influenced the university mission and goals. However, the impact of this recent influence is therefore still not visible.

4.3.1.3. Globalization

More broadly, both discussions of rankings such as *The Times* and the awareness of industry demands also point to the more general influence of globalization. Globalization refers to the increasing interconnectedness and integration of economies, societies, and cultures across the world. Globalization has led to global supply chains, an increasingly mobile engineering workforce, international collaboration, and the transfer of knowledge and technology across borders. At LP-US, faculty often brought up globalization with reference to SD. This role of globalization in faculty decisions to incorporate the SDGs was seen in how they described the role of engineering in SD as well as in the context they provided for their students in the classroom practice. For example, one of the participants brought up the global interconnectedness that is embedded in engineering design and decisions:

> Because green engineering is not: *we have to use wind turbines and solar panels*. It is *let's do some calculations and determine the pros and cons of these. How much energy could you make? What is the payback time? How is it better?* If you talk about electric vehicles, it's not all rosy. We're mining cobalt from the Congo and there are humanitarian disasters in African countries because of mining. So that's a problem that even if you like electric cars, you have to deal with. (US-F04, Pos. 4)

That engineers need to understand the global implications of the decisions they make, especially in the context of SD, was a recurrent theme across the participants. In addition, participants indicated that they were able to provide their students with a global context when addressing the SDGs. One of the participants explained how in one particular course, which also had a study abroad component, students could address the SDGs in a context outside of the US:

> So technically, all of these projects are design build projects for a specific community abroad. And usually they will involve one of the many sustainable development goals. So maybe clean water, education, sanitation, things like that. (US-F01, Pos. 10)

Apart from global rankings and an increased emphasis on study abroad, faculty also recognized the ways globalization had an impact on the way the engineering industry operates, and, like the general concept of industry demand, that awareness was a driver for EESD. In recognition of the influence globalization has on the engineering profession, one of the participants mentioned the ramifications of engineering choices had a global affect and visibility:

> And I was – what got me into sustainable development, and sort of working in that area is, number one, a lot of people I think external to the mining sector don't realize that so much of what has been developed, at least for industry sectors in that way, really started with mining. And has been led by the mining industry. Not just because this is an altruistic group, but because it's such a global and very visible, you know, activity. (US-F03, Pos. 12)

All the participants discussed sustainable development as especially relevant in the global context and framed the SDGs as a relevant and useful framework that is recognized worldwide.

4.3.2. Internal Influences

The institutional mission, the departmental culture and reward structures as well as the programs and course offerings were salient influences in faculty decisions to engage in EESD, though as with the external influences, the internal ones did not emerge as strong drivers of EESD. These influences, defined in Table 4-12 were informed by the faculty and key informant interviews, as well as university websites. The salience of each of these influences is shown in Table 4-13.

Internal Influence	**Definition**
Institutional mission	Institutional mission, vision and goals
Institutional culture	Internal environment and rewards related to faculty recognition and promotion

Pedagogical approach	Programs (institution-level) or courses (department-level) offered

Table 4-12: Definitions of external influences at LP-US

	Institutional mission	Institutional Culture	Pedagogical Approach
F1	X	X	X
F2		X	X
F3		X	
F4	X	X	X
F5	X	X	
F6	X	X	
F7		X	
KI	X	X	X

Table 4-13: Salience of internal influences across participants at LP-US

4.3.2.1. Institutional Mission

Participants noted that the institutional mission, especially given the status of LP-US as a land-grant institution established to serve the needs of its state and citizens, is implicitly aligned with sustainable development, and thus somewhat salient relative to their engagement in EESD. As elaborated in the contextual site description, the university website indicates that LP-US is "a university with global reach and is increasingly recognized as an institution with a worldwide perspective, a commitment to empowering graduates to solve global challenges, and a convening force and top destination for international talent" (US-W09). While the university website does not explicitly mention priorities regarding sustainable development, it discusses initiatives related to inter- and transdisciplinary teams "working collaboratively to address complex problems that impact the human condition" (US-W10). Both key informants and faculty participants identified the alignment between institutional mission and SDGs exists, but saw it as more implicit than explicit, as in the following comments:

> I think the culture of the institution-- and maybe it is part of the culture in terms of [university motto] and giving back. (US-F06, Pos. 4)

> Because we tried this thing on [initiative name] and stuff, right? Why do we need [that university-named initiative]? We have the SDGs that are, like, globally recognized. Everybody knows what they are at this point. So why don't we just use those? (US-F03, Pos. 145)

Like many land grant institutions, LP-US tries to "globalize while maintaining its land-grant, public focus (e.g. access, engagement)" where it seeks an equilibrium between global and local missions (US-W11). Importantly, while globalization, noted earlier, increased both the institution's (through ranking) participants' (through engineering practice) awareness of and commitment to the SDGs, faculty at LP-US also pointed to the conflict between globalization and the land-grant mission. As a land-grant institution, LP-US has a responsibility in providing research-based programs and resources for residents within the state. Accounting for globalization and providing these facilities to all requires balancing the purpose of the land-grant institution and the global demands. One of the key informants elaborated on this conflict:

> [A global land-grant status] demonstrates a problem to understand the value of global education on a systems level, the benefits of it and contradicting goals that are driven by a political sort of agenda is probably-- it's a fair thing to say. And that sort of translates into the university. For example, we want to be a global land-grant university, that means-- if you look at the charge of a land-grant, it's essentially bringing arts, science, and technology to American people. But a global land-grant university then means bringing arts science and technology to all people, but we are state-funded. So they're not going to-- so that's a contradicting sort of premise there. So how can we approach this and say, how can we make the state understand that global education actually benefits you by bringing it to everybody and not just to sort of a national sort of view? (US-K02, Pos. 4)

LP-US's goal to address global challenges also ties in with its goal to seek international recognition. The commitment toward sustainability and climate change is stated in a standalone webpage that includes its SDG Impact Ranking as well as other ranking systems.

> Climate change has become a widely-accepted framework with which to not just set up environmental policy, but set up entire policies for the university. […] We were [in the top 25] in the United States for the Times Higher Education Global Impact ratings, which is not the same thing as the Times Higher Education University Rankings. But

> what this is like, how closely universities adhere to the UN sustainable development goals. And that was mostly incidental, by the way. We have been doing the *Times Higher Education* reporting. And the [administration], on a whim, decided to just report for the impact rating because it was sort of new. And we just happened to do well in the United States. And that got a lot of attention onto our SDG goals. And while that was happening, the climate action commitment was being rewritten with the SDG goals in mind. […] Now, they're a much higher priority in part because we won [top 25] in the United States for the impact ratings. (US-K03, Pos. 4)

This institutional goal to gain global recognition in the Impact Ranking is still new, and the institutional strategies are yet to be defined. While the recent university attention to these global rankings has the potential to provide more support regarding the SDGs and EESD, the concrete, practical nature of that support is not yet clear, and thus while present, it has not yet become a strong influence on faculty's choice to engage in EESD.

4.3.2.2. Institutional Sub-Culture

At LP-US, the faculty who engage in EESD have built a subculture of collaboration and co-teaching that supports their EESD work. This sub-culture was not limited to a department or even the engineering discipline, and it allowed for organic discussions and support among the faculty interested in EESD. For example, one of the participants explained how, through the informal SDG working group, they were able to find other faculty interested in similar research area, or specific SDG that aligns with their area of expertise, across departments and schools at LP-US:

> There is a handful of folks that talk about it in our team to bring [the SDGs] into the classroom, as I understand it. So much of what-- I mean, I'm involved in water research. And so I've put my research hat on. There are a lot of working in [this] research that improves human well-being, and you can directly relate to a specific SDG. And so as an example, the UN World Water day is coming up in two weeks. And the UN has 2023 conference related to the water sustainability goals. And there are 10 of us that are going, and so across different colleges. (US-F06, Pos. 4)

These research and teaching collaborations, mostly initiated by individual faculty, created a culture that emerged as a support for faculty working in EESD and encouraged them to continue their efforts in EESD. Participants also noted that beyond their own courses, they were invited for guest lectures by other faculty at LP-US because of their expertise and focus on sustainability but added that such guest lectures are above and beyond their primary responsibilities towards research and teaching. Due to time constraints, the faculty explained that it was feasible to only accept a few a year:

> I think my biggest challenge is I get asked from multiple faculty to come to guest lectures in their classes. And I just can't do all of it. I mean I, you know, I can't come to every class and do a week-long module on what sustainability means. So, I have to turn those down. Because I'm like, "I just can't. I can't come to five classes and spend, you know, that's five weeks of, kind of, additional instruction." So I do like two or three a year. But I just can't, like, there's more demand for that. That wasn't the case seven and a half years ago. But I think more faculty who have traditional courses recognize why sustainability and resilience are important. And they're playing catch-up, and trying to figure out how to integrate it in their classes. (US-F02, Pos. 68-72)

As the participant notes, the demand for such initiatives has increased over the years at LP-US. While these efforts were primarily initiated at the bottom-up level from faculty wanting to bring SD into their classrooms, they created a culture to share, collaborate and co-teach among other faculty across departments and disciplines. However, these efforts are not recognized rewarded from the institution-level as there are not enough faculty with relevant expertise or interest in EESD at the institution to meet or support the demand. Participants also shared that lack of time and availability was a constraint to engage in this working group:

> So yeah, there was kind of that effort to start getting different people that are doing this kind of stuff to chat and support each other and things like that. So I attended a few of those meetings, but ultimately I couldn't find enough time in my schedule to attend them regularly. But those are, I think, some of the support systems in place to sort of help instructors figure out how they might adapt these things to their personal courses. […] I think that sort of background

> ancillary thing going on, even though I'm not a part of it, I think kind of helps support the culture around sustainability. (US-F05, Pos. 4)

While this institutional sub-culture may have enabled faculty to collaborate and engage in co-teaching efforts in EESD, these faculty-driven efforts were limited because of a lack of time and institutional rewards.

4.3.2.3. Programs and Course Offerings

At LP-US, there were certain programs and courses offered that explicitly address sustainable development or the SDGs in engineering. Because these programs and courses impacted faculty hires, this institutional-level influence reflected the faculty engagement in EESD. The School of Engineering at LP-US offers an elective minor program, for example, which is offered to students from all engineering disciplines, even a few from outside, and focuses on the sustainability principles. Another example is a graduate program offered by the one of the engineering departments at LP-US. Such programs require faculty who have the credentials and expertise in sustainability to teach the relevant courses. Participants mentioned that the faculty hiring process often explicitly looks for certain expertise that can contribute to these specialized coursed:

> So it's a college-- so the [program name] really reports to the College of Engineering. But when I was hired, the college doesn't hire faculty typically. Departments hire faculty. So I was hired because I had green engineering background." (US-F04, Pos. 4)

> In some instances, the sustainability-focused engineering programs look for an overall sustainable engineering background. In other cases, faculty search committees look for specific expertise to teach specialized courses:
> We're hiring new faculty each year that I think have a more interdisciplinary, holistic approach to what infrastructure means, and what it provides. A lot of the faculty that we're hiring, I think, which is good - we don't need more overview people. But, you know, we'll hire a structural engineer that maybe is looking at, like, wood. Cross-laminated timber (CLT). It's like a new technology using wood, but to replace steel in buildings. It's definitely a lot more sustainable. If the wood is sustainably harvest, the building has a

> tremendously lower carbon footprint. And so hiring somebody that knows about CLT as a design product inherently is more sustainable. Because if we can teach a class on this, then those buildings have a much lower kind of carbon footprint. So inherently, it's more sustainable. Do they define themselves as a sustainability person? No. They define themselves as like a wood timber person. (US-F02, Pos. 72-77)

Through such specific programs at LP-US, faculty are hired with the expectation integrating sustainability in engineering. In some cases, they were hired specifically to teach SD-related courses and in other cases, faculty were hired because of SD-related research expertise, and that implicitly filtered over into their teaching.

4.3.3. Individual Influences

While external and internal factors sometimes supported faculty engagement in EESD at LP-US, their decisions to integrate the SDGs into their courses were most heavily influenced by a combination of individual factors, which are listed and defined in Table 4-9.

Individual Influence	**Definition**
Beliefs of SD and Engineering	Beliefs about SD, engineering and the relationship between the two
Previous experiences	Personal, educational and/or work experiences
Beliefs about goals and values of education	Beliefs about the role and responsibility of an educator

Table 4-9 Definitions of individual influences at LP-US

Their beliefs regarding the relationship between sustainable development and engineering influenced their understanding of the importance of integrating the SDGs into engineering education. These beliefs stemmed from their previous experiences, such as academic backgrounds, work experiences, and interdisciplinary collaborations, which provided them with knowledge and perspectives that highlight the relevance of the SDGs. Their teaching beliefs, including values of sustainability, social responsibility, and global citizenship, also shaped their commitment to incorporating the SDGs into their teaching. These three influences led them to

create learning experiences that prepare students to address real-world problems aligned with the SDGs. The presence of each of these influences in the faculty interviews is shown in Table 4-10.

	Previous experiences	Beliefs of SD and Engineering	Beliefs of SD and Engineering
F1	X	X	X
F2	X	X	X
F3	X	X	X
F4	X	X	X
F5	X	X	X
F6	X	X	X
F7	X	X	X

Table 4-10 Salience of internal influences across participants at LP-D

Overall, these individual influences collectively contributed to the engineering faculty's efforts to integrate the SDGs at LP-US.

4.3.3.1. Beliefs about Goals and Values of Education

Engineering faculty's beliefs on the purpose and value of education played a crucial role in their decisions to integrate the Sustainable Development Goals (SDGs) into their courses. These beliefs encompassed their values, philosophies, and pedagogical approaches. Faculty who incorporated the SDGs into their teaching had strong beliefs in the importance of sustainability, social responsibility, and global citizenship.

> Because again, even if you're not calling them sustainable development goals, and you're not listing them one through what have you, it is still very important to me personally, for the program academically, for all of the courses in the course work, to really build, to uplift people. The communities that we serve. To think about that from a design point as a designer. And connect that with what we're doing. It's not all about time and money, it's not all about managing these specific resources in a bubble. We have to think about globally, where is everything coming from, how does it integrate, what are we doing to help those external from what we're doing right here? (US-F01, Pos. 92)

The LP-US faculty in this study viewed engineering education as an opportunity to cultivate future engineers who are not only technically skilled but also socially and environmentally conscious. As another explained,

> I don't think you should force anybody to do it. But I think helping students earlier in their educational careers recognize why these things are important. And, selfishly, how [discipline] engineers make such a big contribution, either positively or negatively, in these things, can attract more students to [discipline] engineering. And a more diverse group of students. Like to – if you want to help people, don't just become a doctor, become a civil engineer, right? So I think there's – so selfishly for the profession, I think we can do a better job of explaining how these things are connected to reach more students. We need to do that earlier in their career. And I think the way to best do that is help them start asking questions early. And use those questions as kind of motivation or agency, like, for their education. (US-F02, Pos. 116-117)

Additionally, faculty who believe in the interdisciplinary nature of engineering solutions saw the SDGs as a framework that allows for the integration of diverse perspectives and knowledge domains and that provides a context for engineering design.

> By including the SDGs, I mean, I think it aligns well with understanding-- I think giving a context to the projects and connecting it to sort of real global issues and problems and things like that, and I think the more sort of aligned or realistic your project is, the more it supports motivation and buy-in and the desire to really dive into the project and support performance and all that. (US-F05, Pos. 4)

Faculty also believed that by incorporating the SDGs and talking about sustainability in the classroom, students would develop the ability to assess scientifically and holistically engineering design choices. Ultimately, they wanted their students to go beyond the emotions around the political climate and think critically about the difficult decisions they make in their profession:

> And I think it helps the students understand how to discuss these things in a scientific way rather than just a political or emotional way, like, "I don't like coal." Like if they have some numbers, they can make a valid argument rather than just saying, "I don't believe this," or, "I don't like this." So I think it gives them-- I think it's a really good critical thinking skill, because green engineering is not: we have to use wind turbines and solar panels. It's: let's do some calculations and determine the pros and cons of these. How much energy

> could you make? What is the payback time? How is it better? If you talk about electric vehicles, it's not all rosy. We're mining cobalt from the Congo and there are humanitarian disasters in African countries because of mining. So that's a problem that even if you like electric cars, you have to deal with. Or if you make plastics, you have to realize that some of that plastic's going to end up in the ocean unless you change the way you design it. So the students have a hard time, I think, not seeing the relevance of this, because it's all around them. (US-F04, Pos. 4)

Ultimately, the beliefs about the goals and values of education influenced faculty to infuse the SDGs into their courses in order to foster engineers committed to addressing a sustainable world.

4.3.3.2. Beliefs of the Relationship between Sustainable Development and Engineering

Engineering faculty's general beliefs regarding the relationship between sustainable development and engineering also influenced their decisions to engage in EESD. Faculty who recognized and embrace the inherent connection between engineering and sustainable development are more inclined to incorporate the SDGs into their teaching, as the following comment illustrates:

> [Engineering and sustainability go] hand in hand. You can't think of them separate. You can't design outside of it. I mean, everything we design now seems like it touches at least one to 10 of these [laughs] sustainable development goals, right? It's everything from water to materials to what do we use, where do we get it from, how are they treat people there. What – yes. It's everywhere. It is, I think, deeply embedded in it. (US-F01, Pos. 134-136)

This participant, like all faculty in the study, viewed engineering as a key driver in addressing societal and environmental challenges, understanding that sustainable development principles must be integrated into engineering practices. They saw the SDGs as a framework for a systems thinking approach, that in alignment with engineering, can guide students to develop innovative solutions that balance technological advancement with social and environmental responsibility. By incorporating the SDGs, these faculty members aimed to instill in their students a holistic

understanding of engineering's role in sustainable development and inspire them to become agents of positive change in society.

> I guess to me it's a holistic, kind of, systems approach to thinking about how we meet the needs of a growing population. And I think sustainable development is generally in the context of globalization, but I think that starts at kind of the local level. And so unique solutions for specific communities, and sustainable development is context-specific. It doesn't look the same everywhere. So I don't know if – that's not maybe a very good definition. But holistic, systems approach, context-specific, local, meeting local user needs. And so unique solutions for specific communities, and sustainable development is context-specific. It doesn't look the same everywhere. So I don't know if – that's not maybe a very good definition. But holistic, systems approach, context-specific, local, meeting local user needs. So I – yes. Primarily, while there's these sustainable development goals, and there's 17 of them, and they're kind of encompassing of the environment and the ocean, and air, and built environment. To me, I as a civil engineer see the ones related to carbon emissions and the built environment and infrastructure being the most critical out of those. The resilience piece as well. Partly because I think to me the carbon is the kind of most – the largest threat to sustainable development in the next 50 years that we need to figure out pretty quickly. (US-F02, Pos. 12-16)

All the participants expressed their strong beliefs on how engineering has a role to play in sustainable development. To address sustainable development in engineering and provide a context for students as they engage in their engineering courses and projects, the participants found the SDGs as a useful framework.

4.3.3.3. Prior Experiences

Engineering faculty's previous experiences, including their academic backgrounds and work experiences, influenced their decisions to integrate the SDGs into their courses. In some cases, faculty members who had received education or training in sustainability, green engineering, or related certificates were hired specifically for the specialized programs and courses offered at LP-US. Additionally, faculty members who have worked in industries or organizations that prioritize sustainable practices had firsthand experience in applying

sustainable solutions to real-world challenges. These experiences shaped their perspectives on the role of engineering in achieving the SDGs and motivated them to incorporate these goals into their teaching. The following excerpt describes an example where the participant's experience in the industry exposed them to green engineering initiatives, which they later brought to LP-US:

> I'm formally trained as a [removed] engineer and [removed scientist. I did a postdoc in [European country] for a year after graduate school. I worked in industry for about 8 years before I came to [LP-US] mainly working on materials processing for the magnetic hard disk industry for computer memory and then for [large pharmaceutical company name] making coatings for eyeglass lenses, hydrophobic coatings, anti-reflective coatings, scratch resistant coatings. […] And [company name] came and said, "Hey, we have a new corporate initiative on green engineering. We have to add this into some of the things we're already doing." […] I was like, "I think this is really interesting." So I volunteered. And I got free training from corporate, right? They sent me to conferences. So that was an unusual case in the late 90s where [company name] was a little bit ahead of the curve and they were training their people internally to make some of their businesses in real-time better in Europe and Australia and Asia. And also, they essentially saw that this was coming to the US. So I volunteered and so I got trained to do that. (US-F04, Pos. 4)

Another faculty explained how their experience in the industry inspired them to pursue a doctoral journey that aligned with SD:

> Between undergrad and grad school, I worked for about a year and a half for a construction company building water and waste water treatment plants. And I went back to grad school, and my master's degree was funded through [federal agency]. And looking at resilience. […] And looking at why residential homes failed, like what was the contributing factor to their failure. I was not there as a structural engineer. I was there as representing contractors. The recommendations that were being made, what effect would that have on the construction industry? And would they be able to find these parts that are being recommended, would it require new training? And so, the report that we helped write contributed to changing the building codes in the United States. And through that experience, saw the power that research could have, stayed for a PhD. My PhD was not as much on resilience as it was more broadly sustainable design and development. And through graduate school and a class I took in undergrad, saw – I learned about principles of sustainability and saw examples of these really – and still today question why these projects are still one off. (US-F02, Pos. 6-8)

Drawing on their previous experiences, engineering faculty wanted to provide students with insights that illustrate the significance of the SD in engineering practice.

4.3.4. Alignment and Interactions between Influences

At LP-US, the interactions between the influences on EESD were primarily observed in a bottom-up manner, as seen in Figure 4-5, shown here again for convenience. Although external and internal factors did contribute to specific faculty hires engaging in EESD, incorporating SDGs in courses was predominantly initiated by individual faculty members driven by their strong beliefs in the purpose of education and the role of sustainable development in engineering. The alignment between these external, internal, and individual influences was not entirely clear due to the polarized political climate in the US and the mission of land-grant institutions to serve local interests. While LP-US, as a land-grant institution, was aligned with external influences, individual faculty participants displayed more independence in their decisions to incorporate the SDGs based on their beliefs and experiences.

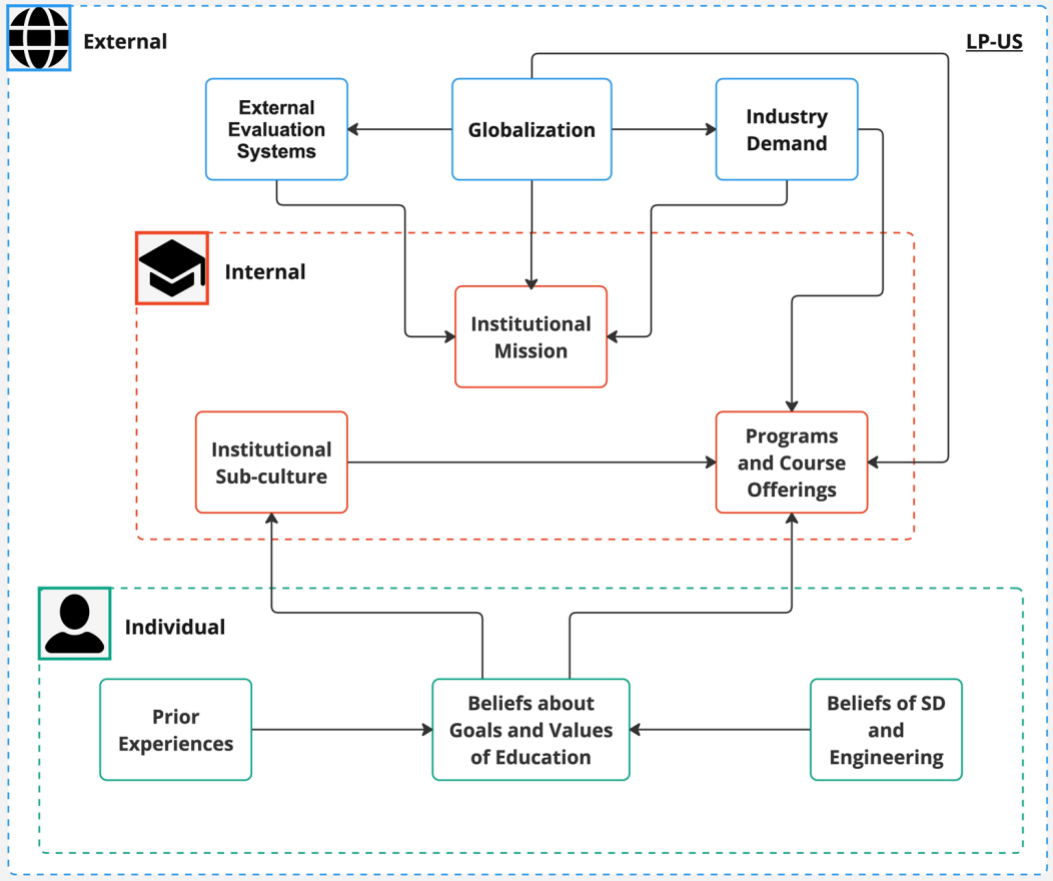

Figure 4-7 Summary of salient influences at LP-US

At LP-US, there were two main approaches to the presence of EESD. One approach was a top-down approach where the university offered programs such as experiential learning and service-learning opportunities to help students understand the complexities of sustainable development on a global scale. These initiatives were indirectly influenced by factors like globalization and industry demands, as LP-US positioned itself as a global land-grant university, requiring a balance between serving local contexts and being a global leader in engineering education. These institutional initiatives had an impact on faculty hires, as they were recruited with the intention of engaging in EESD.

Alternatively, and more commonly, individual faculty members who were not necessarily hired for their expertise and interests in sustainability chose to incorporate the SDGs in their courses driven by their strong teaching beliefs that engineering students should be able to think

critically and approach design solutions holistically, addressing sustainable development broadly and the SDGs specifically. These initiatives were evident not only in the classroom but also through small working groups and interdepartmental collaborations. Faculty participants reported guest lectures and co-teaching approaches, demonstrating the extra efforts they put in beyond the university requirements. While these initiatives were not expected or rewarded, faculty attributed their sustained efforts to academic freedom and self-reward as incentives.

Overall, while both top-down and bottom-up initiatives emerged at LP-US, the impact of the initiatives was limited. The top-down approaches were constrained by the political climate in the country and the land-grant university's identity crisis in striving for global recognition, resulting in localization to specific programs. The bottom-up initiatives driven by individual faculty members varied based on their capacity, time, and resources, remaining localized to their specific courses.

4.4. Comparison Across Sites

While both sites had a combination of external, internal, and individual influences, the strength of these influences varied. At LP-D, external factors such as funding agencies and internal influences such as institutional mission had a strong influence on faculty decisions to incorporate the SDGs. At LP-US, the external and internal influences were not only weaker in comparison to LP-D, but in some instances, they even acted as barriers. While individual influences were strong at both sites, at LP-US, the individual influences were the primary driving influences on faculty decisions to engage in EESD.

4.4.1. External Influences

The external influences at LP-US and LP-D were different and salient in different ways, as shown in Table 4-11. In LP-D where government policies and funding agencies, these factors

acted as barriers for participants incorporating the SDGs at LP-US. Globalization and external evaluation systems were new positive influences albeit limited in impact. At both site, industry demands were salient. However, the ways in which they acted were different.

Influence	LP-US	LP-D
Funding Agencies	Not salient	• Support and encourage SDG alignment
Government Policies	Not salient	• Aligned with SD initiatives
Industry Engagement/Demands	*Industry demands* • Sustainability focus is advantageous	*Industry engagement* • Industry partnerships and employment opportunities for SD areas
Cultural Norms	Not salient	• SDGs introduced in schools • Policies influence funding and industry demands
Globalization	• Sought global recognition • Included international outreach programs • Recognized the global interconnectedness in engineering	Not salient
External Evaluation Systems	• National and international validation and recognition for SDGs	Not salient

Table 4-11 Comparison of external influences

4.4.1.1. Government Policies and Funding Agencies

Government policies have a significant influence on public research-intensive universities, as the policies shape university funding and organizational priorities. While at LP-D, the influence of policies contributed to the EESD efforts, government policies, and political influences were often seen as a barrier for EESD at LP-US. As elaborated in Section 4.2.1.2, how government priorities and policies play a role at LP-D is described by one of the participants:

> Because we need to follow the – half of our budget, of the institute's budget, more than half, comes from external funding. External funding, again, follows all these new directives. That we need to be, I don't know, 100% renewable by

> 2050, and maybe 50% renewable by 2030. And all these big goals politicians make and decide. So we follow on those, because our – the funding calls are also related to these. (D-F03, Pos. 177)

In contrast, the participants at LP-US discussed how policies and the US political climate made engaging in EESD challenging.

> It's also hard because the field is changing so fast than the landscape, and then frankly, the politics of it all with respect to sustainability, climate change. And at times it's [laughter] made it frustrating, you could say. (US-F06, Pos. 4)

> I understand that you have to-- given what state we live in, in terms of how the gubernatorial elections are done every four years, so there could be flips every year, and that's really annoying. So saying we're going to solve climate change or sea level rise could be politically charging. That is very difficult to say. So if you listen carefully to a university, they never say, "Oh, we are the ones that will solve climate change or we are the ones who solve social injustice," or something like that simply because these are politically charged topics that we need to stay away from as an entity. Not as individuals, but as an entity so that we don't get in trouble politically. Because we don't want to lose our funding. Otherwise, we can't do anything. (US-K02, Pos. 4)

While all the faculty participants recognized that policies acted as a barrier, the faculty discussed that they still chose to incorporate the SDGs in their teaching because they wanted their students to be able to understand the political debates scientifically and make informed decisions using data:

> It's interesting because I've changed over. And I keep on rethinking how I do it, because prior to 2015, I think I would initially talk about climate change and defend it in the classroom. I mean, just kind of set-- not defend it, but set it up, "Here's what's going on, and here's the data." Then I went through a stage where I said, "Climate change is a reality folks. Don't question me on it," [laughter] basically was the message. And then it became very politicalized when president Trump was in office. And it got to the point where you couldn't ignore the politics of it. And it was hard because I don't want to come across as a conservative or a liberal person, especially in the classrooms. But it became hard because just there are so many untruths that were out there, and science, in general, was being really questioned, right? And they're kind of like-- there were times when I had to say like, "Here's my opinion of what's going on," because I couldn't keep quiet. And it was extremely frustrating, for sure. And when you're seeing environmental regulation being rolled back and how that impacts people, yeah, so that was hard. (US-F06, Pos. 4)

It is important to note that while government policies generally play a role in faculty decisions at public universities as seen at LP-D, at LP-US, faculty engaged in EESD without the government policies. At LP-US, the individual influences were stronger to counter the lack of this external influence.

At both LP-US and LP-D, research-intensive institutions, external funding support played a big role in faculty research. At LP-D, because funding opportunities for work on the SDGs aligned well with government policies in Denmark and Europe, these opportunities drove the faculty's research agenda and efforts:

> I think about how that's sort of measured, yeah, then there's publications and research projects and getting funding for research projects. And then there is teaching that we do teach and then do well in teaching. And then I guess also when you get sort of further on your career and maybe associate professor then also, things like being part of more strategic initiatives, both internally and externally. It becomes important. But I think in terms of how we are measured and what is rewarded, I think there's a lot of focus on publications and external funding still. […] If you see the EU as well, I mean, the places if you think of funding, then there's a lot of sustainability—sustainability is usually part of the goal that they are trying to achieve. (D-F05, Pos. 4)

As a result of that influence, faculty at LP-D also brought examples of their research projects into the classroom:

> When we talk about courses, well, a lot of the courses are linked to research. I mean there are certain basic courses where – the basic stuff. But we try to keep updating the content of the course. So let's say it follows electric cars right now. What kind of electric drive you have in a car. So even if the course has been there, and has presented – and the title of the course was Control of Converters for Electric Drives. An electric drive could be an elevator, how it's called, a band. All these – you have a huge [electric conveyor belt]. Where in electric car you have more complicated systems, so. The core content of the course might be the same, because we're talking about electric motors, power converters. But the application is updated to match nowadays research. And that's also nice, because then we involve all of our researchers. They can give examples, and then the researchers can also teach. (D-F03, Pos. 191)

At LP-US, in contrast, while funding is an important part in faculty decisions, it was not a positive influence on EESD. As one participant explained, it was difficult to get funding, often due to the lack of support from governmental policies.

> I wanted to write some NSF proposals to engineering education in this area. Like how do we integrate more sustainability and sustainable development into research engineering? And so we partnered and put in a few proposals that were not ultimately funded. And the first two, you know, we got some feedback, we took that. The third one was actually recommended for funding, and then they ran out or something. But the most interesting, the thing I remember, and it was heartbreaking, right, because here I am this new assistant professor. And we submitted a proposal, and it was reviewed well. I think it was the second one we submitted. It was reviewed well by two of the reviewers. And then the third one, I mean, the comments were scathing. And it was – the comments in paraphrasing were something like, "In the time of climate catastrophe, how irresponsible would it be to give money to a [disciplinary program] to integrate sustainable development? I mean that would just be, you know, so irresponsible." And it was one of those things where it was like, oh my gosh, like OK, I get it. So this is political. (US-F03, Pos. 129)

While at LP-D, government priorities and funding opportunities aligned with EESD, at LP-US, participants who tried to apply for funding in this effort experienced rejections. In spite of the lack of support, participants at LP-US continue to integrate SD in their engineering courses.

4.4.1.2. Industry Demands

At both LP-US and LP-D, participants discussed how the industry's focus and priorities on SD supported EESD efforts as it increased engineering graduates' employability.

> I think because there is focus on it in general and in Denmark, it is helpful. And right now, we have a lot of them-- there are a lot of jobs for students like I was, right now. And I think, for example, right now we're building renewable energy projects that are everywhere, so a lot of students-- as long as that sort of focus is there, then there's a need for them. (D-F05, Pos. 4)

> Certainly the industry, I think, is supportive of what we're doing, basically, because they get graduates that are really more on the same page with them, right, when they graduate. So I think industry is quite supportive of it. (US-F03, Pos. 126-127)

The participants from LP-US also discussed how the industry, or the private sector, had an influence independent of the political climate in the country:

> I certainly don't get the sense from industry that the SDGs or the focus on sustainability is political. (US-F03, Pos. 137)

> It helps [students] a lot because they have some of the terminology and understanding of the context of where-- a lot of industry now is thinking about whether or not the slowness behind on the political side-- largely industry is leading-- I mean, industry is leading development. And industry knows that the amount of money that can be made with electrification is humongous, and for example with climate change, knows that we're going to be going carbon neutral, right? And so our students coming out of the program have background in terms of understanding what the limitations are and where and what the opportunities are. (US-F06, Pos. 4)

At both LP-US and LP-D, the industry demand was a positive influence for EESD. However, at LP-D, industry involvement was more driven by engagement and partnerships, while at LP-US, the involvement was driven by meeting the industry's expectations and desired qualifications and skills of engineering graduates.

4.4.1.3. Cultural Norms and Globalization

At LP-D, there was a lot of alignment between the government policies, funding agencies, industry demand and cultural norms. Participants explained that there was a sustainability focused mindset was part of their "DNA" or the Danish culture and society. The cultural norms not only influenced the policies, but also brought in students who then influenced the institutional culture:

> I think here, it's sort of a-- one thing is that you can have a personal drive and think a lot of the people here have that. They are here because they want to change things in a more sustainable direction. And then I think because there's a lot of focus in daily society and there's, I mean, a pull or a push, yeah, for it to also be part of research. If you see the EU as well, I mean, the places if you think of funding, then there's a lot of sustainability— sustainability is usually part of the goal that they are trying to achieve. So in that way, you have to— I think there's a push or a pull towards sustainability from society, so. (D-F05, Pos. 4)

> And in Denmark, that is quite popular. At least among some students, they are very concerned about the future of our planet, and they're willing to spend three or five years of their life studying that and preparing a career in where sustainability plays a role. So we are happy to accommodate that in our educational portfolio. (D-K02, Pos. 4)

At LP-US, while cultural norms were not a salient influence, participants discussed the students' attitudes and interests toward sustainability. This student interest was also expected as most of the programs and courses that integrate SD were electives.

> A lot of students see it. And they're from [U.S. city], and see the nuisance flooding that's happening. And like, yes, guess what? That's only going to increase, right? And they're like, "Well, then why are we like still building in these areas that are like flooding more frequently or whatever?" And it's like, "Well, that's a good question. Why are we doing that?" And so like, you know. So they get it often times, because they've experienced it in some way. So, I think, you know, for students it's either a personal motivation from something they've experienced, or, like, internal to them. Or external motivation of, like, "I can, you know, set myself out from my peers. I can kind of help clients deliver, you know, help them save money. And that'll in turn help me and my career." (US-F02, Pos. 112)

> I think they like to see the connections. They appreciate that the examples are quite realistic and human, right? They're intentionally chosen to elicit some response from students, right? You're going to show SDG examples that really seem to make the world a better place. So I think students like to see those examples. And what we can do in class is we can focus on the engineering parts, which are not-- usually there's not a lot of engineering in the SDG case examples, but you can see that there's a bunch of engineering that was required to make these things happen. So I think the students-- I think they respond to the examples well. (US-F04, Pos. 4)

> The problem that I'm having kind of articulating what the differences are is because I see undergraduate students that are electing to take my classes on [name removed]. And so I'm not getting a true sample of the 700 students in [engineering department]. I'm getting the ones who are already interested in this, so they opted to take my class on it. (US-F02, Pos. 79)

While a subset of students was passionate about sustainability, some were more apathetic. Unlike LP-D, however, faculty at LP-US mentioned the resistance they experienced from students.:

> There have been definitely a-- there have been students that have questions, not climate change, but have said that I've come across as a liberal professor in the classroom. And this is post 2016. Yeah. And when you look at your spot, it's more so like when-- our SPOT as a professor, but my observations-- and I'm assistant department now in my program, and so I get to see everybody's thought scores in the comments. And what I've observed is - and I think about my own - people were very polite up through 2018, 2019. And the language has changed. The politeness and respect part and the constructive comments have changed in terms of what we're reading and what we're seeing. And it's just society has changed in that context. So yeah, you see you still get pushback. (US-F06, Pos. 4)

> I think some students don't really care. But a lot of students are into sustainability, right, and want to work on projects related to that. So there is a subset of students that I think it would really resonate with and then probably a number of students that don't really care. But I don't think there's really students that are anti-sustainability or SDGs or anything like that. So if anything, it's like you're doing something that resonates with part of your students, and then some students don't care. And it's like nobody's going to be anti-SDGs. […] But I will say students that are passionate about sustainability tend to be very passionate, in my experience. So I think that's important. (US-F05, Pos. 4)

The dichotomy in student interest towards sustainability that participants at LP-US mentioned was, in some ways, a reflection of the complex social culture in the US that was discussed in the national context of LP-US (Section 4.1.1.1). This perception about students from the participants also align with the study by Katz et al., Shealy and Godwin (2020), which found that civil engineering students, who were more likely to see global warming as a technical issue rather than a social issue, believed that it would be decades before global warming would affect them.

The increasing interconnectedness and integration of economies, societies, and cultures on a global scale has also influenced the engineering industry and job market. This external influence is salient in LP-US, but not in LP-D. Participants at LP-US referred to the SDGs as a framework recognized globally and used it in their classroom to discuss global challenges. In LP-D, the SDGs were seen as more a part of the Danish culture, and the SDGs were addressed with respect to the problem within the country. Participants at LP-D discussed sustainable energy

solutions and reduced CO_2 emissions which was part of the national vision. On the other hand, most participants at LP-US addressed study abroad programs and collaborating across borders to address the SDGs.

> So technically, all of these projects are design build projects for a specific community abroad. And usually they will involve one of the many sustainable development goals. So maybe clean water, education, sanitation, things like that. (US-F01, Pos. 10)

> I think sometimes a lot of our students in engineering don't do study abroad and haven't been exposed to other parts of the world and understanding that we're pretty lucky here in the United States. And so they don't have the cultural background or competency to really appreciate that. And so I suppose that's hard for me in terms of like-- I mean, I only have my living experience, and I know what most of the kids don't have. And yeah, so it's a little bit hard at times from that perspective, I would say, yeah. (US-F06, Pos. 4)

4.4.1.4. External Evaluation Systems

External evaluation systems, such as accreditation boards and ranking systems, were never mentioned by any of the participants at LP-D but came up in the interviews with participants at LP-US. Although LP-D is highly ranked in the Times Higher Education Impact Ranking, neither the faculty nor the key informants referred to it. At LP-US, on the other hand, faculty and key informants mentioned how it was a recent influence that interested the institution. As it was a new influence, participants said that the impact was yet to be seen.

4.4.2. Internal Influences

Influence	LP-US	LP-D
Institutional Mission	• Implicit alignment	• Explicit alignment
Institutional Culture	• Implicit institutional and departmental culture for SD • Academic freedom • No rewards for EESD	• Explicit institutional and departmental culture for SD • Academic freedom • Rewards for SD research • No rewards for EESD
University Programs and Curriculum	• Localized programs and course offerings on sustainability in engineering	• Seamless integration of SDGs through PBL

Table 4-12 Comparison of internal influences

At both LP-US and LP-D, the same three internal influences were salient in the faculty decisions to integrate the SDGs: institutional mission, organizational culture and reward structure and university programs and departmental courses. However, the ways in which these influences affected faculty decisions and the strength of the influences varied. At LP-D, there was an explicit alignment between the institutional mission and the SDGs. As described in Section 4.3.2.1, the university websites, the university atmosphere, and the university's mission were explicit in LP-D's priorities to sustainable development. This alignment was also reflected in the organizational culture and reward structures. Faculty discussed how it was in their advantage to align their research goals to the institution's missions for internal funding opportunities. At LP-D, funding was the incentive and quantifiable measure for promotions. As a result, faculty's research agenda was explicitly aligned with the SDGs and this trickled to their teaching, as they were able to effortlessly connect engineering with the SDGs in their courses. In addition, influence of the university's mission was clearly evident in the university programs and courses offered at the departmental-level. Some of the project-based courses at LP-D were specifically focused on one of the 17 SDGs. At LP-US, on the other hand, the institutional mission was not explicitly aligned with the SD or the SDGs. However, as a land-grant institution, the university was broadly driven for the betterment of the land and society and thus, implicitly aligned with the SDGs. While the university offered several sustainability-focused engineering programs and courses, the integration was not as seamless in other engineering programs and courses. Here, the integration of SDGs in other courses was initiated by interested faculty with the academic freedom they had. While the reward structures were similar to those at LP-D where there no rewards for this integration in their teaching practices, unlike LP-US, there were no internal incentives for faculty to align their research to the SDGs. Therefore, the integration of SDGs in

teaching practices often required additional effort in comparison to that of LP-US. In summary, due to the explicit alignment between the SDGs and the institutional mission, the internal culture and programs at were more conducive for faculty to integrate the SDGs in their teaching at LP-D than at LP-US.

4.4.3. Individual Influences

The participants at both LP-D and LP-US had strong individual influences that led them to integrate the SDGs in their courses. All the participants acknowledged that engineers play a role in a sustainable future. Participants also acknowledged the limitation of engineers, explaining that policies and societal behaviors too must work towards sustainable development. Due to the strong external and internal influences at LP-D, the strength of the individual influences relatively could not be compared. Faculty at LP-D did not face any barriers or resistance in their teaching experiences. In fact, the integration of SDGs in courses was normal practice at LP-D. In contrast, at LP-US, in spite of the weak external and internal influences, the strength of the individual influences was very evident. Most participants included the SDGs in their courses because of their strong beliefs, teaching philosophy and past experiences. At LP-US, some faculty with an academic background in sustainability concepts were specifically hired to teach specialized programs and courses. While participants at both sites were inclined to EESD, the individual influences often outweighed the external and internal barriers that faculty at LP-US faced.

Influence	**LP-US**	**LP-D**
Prior Experiences	• Industry experience • Global experience • Academic background	Not salient
Belief of the Relationship between SD and Engineering	• Strong belief and expectation of engineering to contribute to SD	• Strong belief and expectation of engineering to contribute to SD

Beliefs about Goals and Values of Education	• Want students develop the skills and thinking to address engineering problem holistically	• Want students develop the skills and thinking to address engineering problem holistically

Table 4-13 Comparison of individual influences

4.5. Summary

LP-D and LP-US are both large public, research-intensive institutions that have made efforts to integrate the SDGs into their engineering programs. However, the external and internal influences affecting EESD practices at both sites had discernible differences in how they affected the individual influences. Faculty at LP-D had several supporting external and internal influences that enabled that to engage in EESD. In the context of engineering programs, LP-D incorporated the SDGs by immersing students in real-world projects and case studies centered around sustainability and social responsibility. Through interdisciplinary collaboration, students are empowered to tackle intricate challenges aligned with the SDGs, emphasizing the practical application of their engineering disciplines. Conversely, LP-US, also integrated the SDGs within its engineering programs, albeit with a slightly different emphasis, such as specialized programs and global outreach learning programs. Where LP-D had a more consistent alignment across the three levels of influences, faculty at LP-US expressed a lot of barriers on the external and internal levels. In spite of the barriers, faculty, due to their strong individual influences, engaged in EESD practices.

5. Discussion

The purposes of this exploratory comparative case study were 1) to understand the influences that support engineering faculty choices to integrate the SDGs in their courses, and 2) to investigate how these influences may differ across national and institutional contexts. To achieve these goals, the study aimed to answer the following research questions:

RQ 1: What individual, internal, and external influences support engineering faculty choices to integrate the SDGs in their courses?

RQ 2: How do the influences vary across sites?

Using case data from two universities in the U.S. and Denmark, I identified the external, internal, and individual influences that supported faculty decisions, how the influences interacted with each other within the site, and how they varied across sites. The findings revealed notable differences between the two institutions, highlighting the significant role of external and internal influences at LP-D and the strong individual influences at LP-US. At LP-D, faculty decisions on the integration of the SDGs were heavily influenced by the national and institutional context that emphasized both sustainability broadly and the SDGs in particular. While individual influences did exist, they were heavily supported and dominated by internal and external ones. At LP-US, on the other hand, the integration of the SDGs was predominantly influenced by individual beliefs and initiatives. While participants did identify areas of alignment between EESD and broader external and internal influences, those influences seemed primarily to support rather than drive participants' inclusion of the SDGs in courses. The findings from my study add to the broader conversations of the complexities in faculty decision-making and contributes to the research gap in the context of EESD. In this chapter, I situate my findings with the existing literature.

5.1. External Influences

Findings from this study revealed the differences in the external factors that played a role in shaping faculty decisions to engage in EESD. LP-D is situated in a national context that embraces the SDGs and sustainability broadly both within the country and through its participation in the EU and Nordic Council. As a result, cultural norms, government policies, funding agencies and industry partnerships are all prominent sources of support for the SDGs, and in turn influenced faculty choices to engage in EESD at LP-D. In the U.S., in contrast, sustainability initiatives tend to be more politically polarized, and the SDGs are far less prominent at a national level (evidenced by the country's withdrawal from the Paris Agreement under the Trump Administration). Thus, at LP-US, participants' awareness of globalization, the presence external evaluation systems, and perceived industry demands were factors that played a role, albeit weak one, in faculty choices to engage in EESD.

While external influences were salient at both sites, they had a more dominant role in faculty decisions at the LP-D site, which in turn, resulted in a more consistent and uniform integration of the SDGs in engineering education. The presence of cultural norms and government policies that aligned well with SD contributed to the sociocultural context that enabled faculty to effortlessly integrate the SDGs in their courses. Just as how Lattuca and Pollard (2016) discussed how the sociocultural context of institutions can play a role in decisions "sometimes without conscious attention" (p. 94), the sustainability mindset was an integral part of the cultural norms in Denmark, and it was reflected both outside and within the institution. The heavy presence of external influences, including cultural norms, dominated the individual influences at LP-D. When asked about their choice to incorporate the SDGs in the curricula, faculty at LP-D said, "It is in our DNA," referring to their collective identity as a member of the

institution and the country. In addition, the role of government policies was highly visible in the LP-D context, especially in the ways that they influenced the culture and attitudes of incoming students as well as the funding agencies and research drives. These, in turn, facilitated and supported the integration of SDGs in the curricula. The strong presence of both cultural norms and government policies both aligned well with sustainable development initiatives in education.

The findings at LP-US demonstrated a clear absence of strong external influences. Government policies that fluctuated depending on the political party in power and polarized public views on sustainable development acted as barriers, not supporting influences toward faculty decisions to engage in EESD. One of the salient external influences that emerged at the LP-US site was globalization. The Engineering Education Coalitions, an initiative supported by the National Science Foundation that addressed the "ability of U.S. industry to be competitive in the emerging global economy through rapid and successful innovation" is an example of where globalization influenced a curricula reform (National Science Foundation, 2000). In relation to globalization, external evaluation systems that look at the global ranking of universities also have played a role in the integration of SDGs in engineering education at LP-US. As Lattuca and Pollard (2016) list accreditation standards as a commonly reported external influence on curricular change, the ranking systems have emerged to be an important factor and priority at various higher education institutions(Menon, Webb, et al., 2023). However, these external influences, when not supported by government policies and cultural norms have a limited impact on faculty decisions.

The relationship between EESD and the larger national context is not surprising. The role of government policies on faculty decisions and curriculum change has been reported by Lattuca and Pollard (2016) and Lattuca and Stark (2009) as they account for the variation in strength

depending on the priorities. More broadly, national policies and cultures have shaped the nature of engineering education, from driving the transformation of engineering education from "occupational training" to "professional training" during postwar efforts (Akera & Seely, 2015, p. 20), and influencing engineering education for ethics through accreditation efforts (Martin et al., 2021), to preparing engineers to serve their home country (Downey & Lucena, 2005). Similarly, globalization itself has had an impact on engineering curricula since the 1990s (Lucena, 2003, 2006). With the "increased mobility of engineers in the workplace," (Lucena et al., 2008, p. 433), globalization has changed the practice of engineering and engineering education, and that influence was evident in the discussions of LP-US faculty.

Within the U.S. in particular, the example of the Engineering Education Coalition, which "was established to create great broad-based institutional collaborations, bold, innovative, comprehensive new models for undergraduate engineering education" (Borrego et al., 2007) represents one of the more recent intentional efforts to use national policy – in this case, funding from the National Science Foundation – to shape engineering education curricula. However, that project also indicated that while funding supports can have a positive influence on research and teaching practices (Dalal et al., 2023; Finelli et al., 2014), funding alone is not sufficient. As Borrego et al. indicated, the curriculum reform struggled to represent the desired innovative transformation due to the absence of cultural norms or the "people" aspect (Borrego et al., 2007, p. 5). A similar pattern emerged in the U.S. in response to *The Engineer of 2020* report by the National Academy of Engineering (2004): while the report may have driven research funding, a recent survey of civil engineering departments showed limited progress on many of the key attributes advocated by the report (Bruhl et al., 2021). In Denmark, national policies and funding initiatives were successful, but these influences were also supported by the larger cultural

context, which starts at the early schooling level and that permeates the Danish culture in a way that is not seen in the US culture. Where Borrego et al. (2007) identified the lack of consistent conviction among faculty, administrators, and other engineering education researchers to support the Engineering Education Coalition efforts, this dissertation study, in essence, highlights the dichotomy of sustainability perspectives broadly in the US as a barrier in efforts toward EESD. Thus, this study confirms and emphasizes that without the support of the cultural context and government policies, the integration of sustainable development in engineering education is limited.

5.2. Internal Influences

Internal influences, such as institutional mission, vision, and culture, along with reward structures across engineering departments, play a significant role in faculty decisions regarding the integration of the SDGs in engineering education. Institutional mission, and the overall pedagogical philosophy of each institution influenced the implementation of EESD. At LP-D, the strong emphasis on PBL aligns well with EESD, creating a conducive environment for faculty engagement in sustainability practices. Whereas at LP-US, the institution's recognition of the potential impact of globalization is apparent, led to specific programs and courses that presented SD and the SDGs in a global context.

Institutional culture, as emphasized by Finelli et al. (2014), Pifer et al. (2016) and Austin (1996), plays a significant role in shaping faculty decisions. Different types of institutions, such as liberal arts universities versus technical universities, have distinct cultures and missions that influence faculty choices, especially in balancing teaching and research (Austin, 1996; Pifer et al., 2016). The findings from this study similarly showed how the alignment between institutional mission and the SDGs serves as a powerful internal influence, motivating faculty to

prioritize the integration of the SDGs into their research, and indirectly, their teaching practices. In addition, as Borrego et al., (2010) pointed out in their study of adoptions of engineering education practices, departmental and institutional cultures play a role in how faculty engage in pedagogical approaches. This was evident in LP-D's commitment to PBL and the SDGs, which fostered a local climate that encourages faculty engagement in EESD (Guerra, 2017, 2017), thus, showcasing the impact of institutional culture on faculty decisions.

As scholars have indicated, the prioritization of teaching or research within academic institutions is shaped by leadership, reward structures, and the resulting culture. Previous studies have shown that departmental environment and reward structures within the institution influence faculty allocation of time to teaching, research, and service (Blackburn et al., 1991; Fairweather, 2002; Huang et al., 2007; Lattuca et al., 2010; O'Meara & Campbell, 2011). Both LP-D and LP-US prioritize academic freedom, allowing faculty members to integrate the SDGs in their courses based on their own judgment. Additionally, academic freedom enables collaboration among faculty members across departments and institutions, promoting initiatives like co-teaching and guest lectures. However, faculty at LP-US expressed the inability to keep up with their interests in engaging in EESD due to lack of rewards. This complements the findings of O'Meara & Campbell (2011) that departmental rewards that allowed faculty to find a better balance between work and life contributed to faculty's sense of agency in their teaching decisions. The discrepancy in recognition between research and teaching, which Austin (1996) highlighted, was seen at both cases where research received more focus and recognition. This finding is supported by faculty at LP-US who were not rewarded for incorporating the SDGs in their teaching efforts, and at LP-D, faculty were incentivized for research aligned with the institution's missions, but not for teaching.

LP-US, as a land-grant institution grappling with globalization trends in engineering, had strategic goals to address sustainability in education, but these efforts were limited to specific programs and courses. The inconsistent culture at LP-US was apparent in that participants at LP-US cited ways in which the institutional mission theoretically aligned with and supported EESD, but did not represent a widespread or dominant driver pushing faculty to integrate the SDGs into courses. Their experiences are markedly different from participants at LP-D, where a clear vision was communicated to its faculty members across departments. As a result, faculty members were more likely to perceive the integration of the SDGs as a means of fulfilling the institution's vision and strategic priorities. This linkage also echoes findings from Finelli et al. (2014) about the importance of institutional context and departmental support to affect change in instructional development. This was evident at LP-D, where faculty were provided increased support and resources, such as internal funding grants, for sustainability-focused research and teaching practices, resulting in a more consistent engagement in EESD compared to LP-US.

Overall, internal influences, such as institutional mission, vision, culture, and pedagogical approaches, significantly impact faculty decisions regarding the integration of the SDGs in engineering education. Institutional alignment with the SDGs and support for faculty efforts, coupled with academic freedom, contribute to the seamless integration of the SDGs into courses. The institutional culture and context hold substantial influence, shaping faculty engagement in EESD, possibly even in the absence of broader national promotion of sustainability.

5.3. Individual Influences

In the absence of strong external or institutional drivers such as those seen at LP-D, EESD at LP-US was driven predominantly by individual beliefs and experiences. At institutions similar to LP-US and LP-D, where faculty had academic freedom and the autonomy to shape the

curriculum and incorporate sustainability principles and practices into their courses, faculty can draw on their own beliefs, experiences, and expertise to integrate sustainability into their teaching. This finding is consistent with studies that have demonstrated the ways that individual faculty members have the agency to bring about changes in curriculum, particularly within the context of higher education in the United States. Studies by Borrego and Henderson indicate that when individual faculty members engage in emergent changes through faculty learning communities, such as those seen at LP-US, the individual educators act in the role of change agents (Borrego et al., 2010; Borrego & Henderson, 2014). Studies have shown that faculty members' beliefs and attitudes towards sustainability play a significant role in their willingness to incorporate sustainability into their courses. For example, Weiss et al. (2021) found that faculty members who have a strong belief in the importance of sustainability are more likely to integrate sustainability into their teaching, which was reflected in the faculty at LP-US where beliefs of education, SD, and engineering influenced faculty choices to engage in EESD. Similarly, faculty members' experiences and exposure to sustainability initiatives and resources can also influence their decision to incorporate sustainability into their teaching. For instance, faculty members who have participated in sustainability workshops or professional development programs are more likely to integrate sustainability into their courses (Chen et al., 2008). As seen at LP-US, faculty decisions to incorporate the SDGs were influenced by their academic and industry experiences that exposed them to green engineering and sustainability practices. Additionally, according to a study by (Castellanos and Queiruga-Dios (2021), faculty members who have access to resources such as case studies, teaching materials, and assessment tools related to sustainability are more likely to incorporate sustainability into their courses (Castellanos & Dios, 2021). Faculty at LP-US reported that they found engagement in the SDGs working group useful to share ideas and

resources, and that the community of practice was helpful to continue engaging in EESD. However, the lack of institutional rewards and recognition acted as barriers, even in their participation in the community. As Menon et al. (2023) indicated in identifying supports and barriers to interdisciplinary education, while faculty choices were driven by individual influences, lack of time and reward structures acted as costly barriers, resulting in burnout. While individual agency is crucial in driving EESD practices in the absence of strong external or institutional drivers, as Borrego and Henderson (2014) point out, these change practices are limited in their outcome and rarely result in a widely adopted practice.

5.4. Summary

These findings integrate and extend prior work on the influences of external, internal and individual factors in engineering education. As the literature indicates, the external factors, such as national priorities and the socio-political climate, played a role in the variation of how faculty engage in EESD between the two sites, primarily due to external factors looks like around the world, and link them specifically to EESD. In addition, where the majority of EESD research has studied student learning and effective pedagogies, the widely adopted PBL practice at LP-D enabled showed how leveraging these learning approaches can enable faculty engagement in EESD. Finally, while studies in EESD have shown that interest exists among faculty to embed SD into engineering faculty, these interests and beliefs alone is not enough to drive consistent educational reform.

6. Conclusion

The study findings contribute to the field of engineering education, especially in the area of engineering education for sustainable development, because they indicate the need for strong external and internal influences to support faculty decisions and teaching practices. The power of national policies and cultural norms, for example, played a crucial role in the local context of LP-D, which in turn, shaped the institution's vision and culture to engage in EESD. The findings also emphasized the limits of strong individual influences when paired with weak external and internal influences. While faculty at LP-US were change agents who played a role in shaping the institution's culture and select courses, their efforts were limited to localized instances. Thus, to truly have an impact on EESD and support a widespread practice of the integration of SD in engineering education, strong external and internal influences must be present.

While individual influences can play a vital role in initiating and implementing educational reforms, as Graham (2012) and Lattuca and Pollard (2016) pointed out, successful and lasting educational reform requires buy-in not only at the individual level but also at the departmental and institutional levels. Individual efforts alone may not be sufficient to drive sustainable reform. At LP-D, the practice has received institutional buy-in. This indicates that the institution as a whole has recognized the importance of integrating sustainability into engineering education and has provided support, resources, and institutional structures to facilitate this integration. The commitment to EESD at LP-D extends beyond the efforts of a few individual faculty members and is deeply embedded in the departmental and institutional culture. The convergence of individual, departmental, and institutional influences at LP-D contributes to the success and longevity of EESD initiatives.

On the other hand, at LP-US, EESD appears to be driven primarily by a handful of faculty members. This suggests that the institutional buy-in and support for EESD may be more limited or in its early stages of development. While individual faculty members may have a strong commitment to incorporating sustainability into their courses, the convergence of these individual efforts with departmental and institutional influences may still be at its initial stages. There is room for more coordinated efforts and collaboration to ensure a more comprehensive and sustainable integration of the SDGs into engineering education at LP-US. Graham (2016) challenges the notion that individual influences alone can lead to sustainable educational reform. Kezar (2012) addresses the contradictions by suggesting that both top-down (institutional) and bottom-up (individual) initiatives are necessary and should converge for successful institutional change. In the context of EESD, this convergence is vital to ensure the long-term impact of sustainability integration in engineering education. While EESD has received institutional support at LP-D, indicating a convergence of individual, departmental, and institutional influences, LP-US may still be in the early stages of achieving such convergence. The challenges and complexities of educational reform suggest that a combination of both top-down and bottom-up efforts is essential. By aligning individual faculty initiatives with departmental and institutional influences, institutions can create a more coordinated and sustainable approach to integrating the SDGs into engineering education.

6.1. Implications for EESD

The implications of this study are twofold. First, the findings highlight the importance of strong external and internal influences in shaping faculty decisions to incorporate the SDGs in engineering education. National policies and cultural norms play a significant role in creating a supportive environment for faculty to integrate sustainability into their teaching. Institutions need

to actively align their vision, culture, and resources with the principles of sustainable development to foster a widespread and consistent practice of EESD. Secondly, the study underscores the limitations of relying solely on individual influences. While individual faculty members can be change agents and drive localized initiatives, their efforts may not be sufficient to bring about widespread curricular change. Faculty decisions should be supported by robust external and internal influences that provide the necessary structures, resources, and institutional commitment for a widespread sustainable development integration in engineering education. These findings have important implications for engineering education, particularly in the context of EESD. Institutions and policymakers need to recognize the importance of creating a conducive environment that aligns external influences, such as national policies, with internal influences, such as institutional vision and culture. By providing internal incentives for research and teaching, and providing a community and culture where faculty have the time and resources to engage in the exchange of ideas and teaching practices, institutions can support faculty in their decisions to incorporate the SDGs and foster a comprehensive and sustained integration of sustainable development principles into engineering education. Overall, the study contributes to the field of engineering education by highlighting the significance of external, internal, and individual influences on faculty decisions to incorporate the SDGs. It provides valuable insights into the complexities of curricular reform and emphasizes the need for a multifaceted approach to promote EESD effectively.

6.2. Recommendations and Effective Practices for EESD

To engage in a consistent practice of EESD, programs, faculty, faculty developers, and university administrators can consider the following recommendations.

- Efforts should be made to strengthen external influences by advocating for supportive national policies and funding that incentivize the integration of sustainable development in engineering education. The Coalitions serve as an example of how funding priorities can help shape education even in a country as diverse as the U.S.
- Internal alignment is crucial, requiring institutions to align their vision, culture, and resources toward sustainable development. This can be achieved by incorporating the SDGs into institutional mission statements, strategic plans, and curricular frameworks, as well as promoting interdisciplinary collaboration.
- University administrators can establish partnerships with industry, government agencies, non-profit organizations, and other academic institutions to create collaborative opportunities for EESD. Collaborative projects, joint research ventures, and industry-sponsored initiatives can provide students and faculty with practical experience in tackling real-world sustainability challenges. Administrators should actively seek funding opportunities and establish memorandum of understandings (MOUs) with external partners to enhance the impact and reach of EESD efforts.
- To build a culture and awareness of sustainable development and the SDGs, unit across the institution should clearly and visibly communicate either the SDGs specifically or SD more broadly. Such communication can include mission and vision statements, posters, information on web sites, and more. At the same time, such communication should allowing faculty to connect with the SDGs in a way

that resonates with their career and personal goals to foster an inclusive, engaged culture that aligns towards SD.

- University administrators can prioritize the recruitment of faculty members with expertise in sustainable development and engineering. By creating dedicated positions or including sustainability as a key criterion in hiring decisions, institutions can ensure that the faculty body possesses the necessary knowledge and passion for EESD.
- Adequate resources, both financial and material, should be allocated to support EESD initiatives. This allocation includes funding for research projects related to sustainable engineering solutions, the establishment of dedicated laboratories or centers focused on sustainability research and education, and access to updated educational materials and technologies.
- Empowering faculty through professional development opportunities and communities of practice focused on EESD will enhance their overall pedagogical approaches to integrating the SDGs into engineering courses. These initiatives, supported by centers for teaching and learning or similar units, can equip faculty with the pedagogical skills and content knowledge needed to effectively integrate sustainable development principles into their courses. Faculty must have time and peer support/mentoring to both learn and implement these new pedagogies and implement them.
- While interdisciplinary collaboration among faculty members from various disciplines and co-teaching initiatives with other universities are essential to

address complex sustainability problems, these efforts need to be recognized and rewarded within their departments and institution.

By considering these recommendations, programs, faculty, faculty developers, and university administrators can contribute to the establishment of a consistent and effective practice of EESD in engineering education.

6.3. Limitations

This exploratory comparative serves as a first step towards understanding the influences and factors that support faculty in EESD practices. However, there are several limitations in this study. One limitation of this comparative case study design is the limited number of cases. In my design, studying the faculty at a single institution in each country limited me in how much I can attribute the findings to national contexts. While more cases would have strengthened the findings, my findings across two cases are supported in conjunction with the literature. Another limitation was that English was not the primary language at LP-D. This affected the document artifacts I had access to during my analysis, as the undergraduate education in conducted in Danish. In addition, the interviews were conducted in English, but English is not the national language of Denmark and thus may not be the primary language of my participants at LP-D. As a result, participants may have been limited in how they expressed their individual influences of beliefs and values, and thus these influences may in fact have a stronger role than the interviews suggested.. However, while the presence of individual influences was limited at LP-D, it is useful to note that the external and internal influences were discussed in detail across the interviews, indicating that language was not a limiting factor in those discussions. Thus, the data and analysis can speak to the presence of an influence, but not necessarily to the absence of one. In spite of these limitations, the findings from this comparative study does serve to highlight the

role played by the institutional and national contexts and illuminate the need for more comparative work.

6.4. Future Work

There are many directions future work for this study could head. One direction is to include more cases to capture how the external and internal influences differ in different countries and different types of institutions. By exploring more countries, the different external influences can be captured. For instance, in this study, I looked at two countries, both members of the UN and both part of Global North, but different levels of SDG performances. Looking at countries from Global North and Global South or signatories and non-signatories on Paris Agreement would broaden our understanding on role of the external influences on EESD. In addition, by including more institutions within the same country, the role of internal influences can be studied in more depth. In United States, for example, looking at another large public doctoral institution that explicitly includes sustainable development in their vision would be useful to understand how strong internal influences play in the absence of strong external influences. This could also be extended to look at different types of institutions, such as teaching-focused universities and Liberal Arts colleges.

Furthermore, future research should consider how these influences relate to effective EESD practices. While I had some insights on how participants in this study varied in their approaches to integrate the SDGs, as it was out of scope, I did not explore the correlation in depth. By capturing more perspectives, a larger study would be helpful to identify the impact of how different combinations of influences work in the faculty decisions and their teaching approaches toward EESD.

Finally, while the analysis in this study focused on factors that supported faculty engagement in EESD, the interviews at LP-US in particular also surfaced a number of barriers to EESD, as suggested by some of the excerpts included in the findings. While a full exploration of those barriers is outside the scope of this dissertation, future work could probe this data more fully and gather additional data to examine these barriers to understand why faculty *do not* engage in EESD. Given that the participants in this study at LP-US voluntarily engaged in EESD predominantly due to individual influences, in spite of external and internal barriers, it would be useful to explore the barriers faculty experience while engaging in EESD as well how those deterring influences affect their decisions to incorporate the SDGs in their courses. To further explore this direction, looking at engineering faculty mental models to understand faculty beliefs of EESD would be a viable approach.

6.5. Concluding Remarks

When I started this journey, I thought that sustainable development was the most suited term to capture what I believed engineering and education should strive for. I saw it as encompassing the environmental, economic, and social aspects of development. I have now come to realize the limitations of this term, both in its definitions and interpretations, as well as the political connotations it carries. As I observe initiatives aimed at broadening participation in engineering education, I find myself associating them with efforts towards EESD, as such initiatives address, at least, two of the SDGs, if not three. In a way, I believe that our field is actively engaged in EESD more than we realize, but due to the ambiguity surrounding the term, we fail to recognize our own efforts. Perhaps sometime in my career, I hope to further explore and refine the concept of EESD, considering the evolving landscape of engineering education and the changing global challenges we face. This is just the beginning.

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Appendix A

Faculty Recruitment Email Template

Subject: Opportunity to Participate in Engineering Education Research Study

Dear engineering faculty,

My name is Maya Menon, and I am a Ph.D. Candidate in Engineering Education at Virginia Tech, working with my advisor, Dr. Marie Paretti.

For my dissertation research, I am conducting a global study about faculty experiences in integrating the UN Sustainable Development Goals (SDGs) in their engineering courses. Your name/contact information was passed along to me by [participant name/site coordinator name]. It was suggested that you may be interested in participating in my research study. I would like to invite you to participate in the study, as your opinions and insights about your teaching experiences are critical to this research (Virginia Tech IRB #22-476).

Participation would involve one interview lasting approximately one hour. The interview would occur in the next few weeks in person or by Zoom, and we will discuss your experiences teaching courses.

Your responses will be kept confidential. Published results will include summaries of responses, and any direct quotes will be assigned to a pseudonym of your choosing.

If you are interested in more information in participating in the study, please complete this electronic consent form and use this link below to schedule an interview.

Here is the link to the electronic consent form:
[insert link]

Here is the link to schedule an interview. [Note that the calendar should automatically adjust to your time zone. Interview slots are available from (insert times and time zone).]:
[insert link]

If you have any questions or concerns, please feel free to email me at mayamenon@vt.edu.

Sincerely,

Maya Menon

Appendix B

Interview Protocol

This study will use semi-structured interviews and address questions such as those below. However, because the interviews are semi-structured, the exact wording of the questions may vary slightly, and follow-up questions may be included to elicit additional information around these topics.

Thank you for making time to chat with me today. I'm curious to hear about your experiences in fostering the United Nations Sustainable Development Goals (SDGs) in your engineering courses. I want to hear about your experiences in your own words, so I may ask you questions that I may already know the answers to. Think of this as us capturing a record of your experiences.

Before we get started, do you mind if I start an audio recording?

1. To start off, could you tell me about your background?

Prompts:

a. Educational background
b. Work experience
c. Years of teaching
d. Current role and research interests

I would like to understand your perspectives on sustainable development.

2. How do you define sustainable development?
3. How do you describe the relationship between sustainable development and engineering?

Next, I would like to know more about the courses you teach and your experiences teaching them.

4. Could you tell me about a course in which you've included the SDGs (or planning to integrate them if you aren't currently including them)?

Prompts:

a. Why did you choose that course (to incorporate the SDGs)?
b. Which SDGs are incorporated?
c. Is it a required course or an elective?
d. How long have you taught the course?
e. What do you want your students to gain from your courses (as related to SDGs)?
f. What challenges have you faced in the courses designed for SDGs? How do they differ from other courses?
g. Will you continue to incorporate the SDGs into that course? Why?
h. What kind of feedback have you received from students who have taken your course?
i. Where do you not integrate the SDGs? Which courses, and why not?

5. Are there other courses you teach where you incorporate the SDGs? If so, how are they similar to and different from the course you just described?

6. How does integrating the SDGs into teaching align with your personal, research, and career goals?

Now, I want to understand the departmental and institutional culture.

7. How does sustainable development or the SDGs show up in the culture of the institution?
    a. What makes it look this way?
    b. How does it affect faculty, staff and students?
    c. How would you like it to be? What should it look like?
    8. How does your department include or address the SDGs?
    a. What other courses or experiences that you are aware of, incorporate the SDGs in your department?
    b. How does the department view the integration?
    c. How is it rewarded, supported, and/or aligned with department/institution vision?

I want to zoom out a bit more to understand why incorporating the SDGs may be valuable to students.

9. How do the SDGs fit with national priorities?
10. How does the incorporation of SDGs help students when they enter the workforce?

Is there anything else you would like to add about integrating the SDGs into your teaching?

Appendix C

Key Informant Interview Protocol

This study will use semi-structured interviews and address questions such as those below. However, because the interviews are semi-structured, the exact wording of the questions may vary slightly, and follow-up questions may be included to elicit additional information around these topics.

Thank you for making time to chat with me today. I'm curious to hear about your experiences in fostering the United Nations Sustainable Development Goals (SDGs) in the university's engineering curriculum. I'm interested to hear about your perspective about how you, your department, and/or your university integrate the sustainable development goals in education. I'm curious about the department-level or institution-level decisions and your expertise on how national policies or culture inform these decisions.

Before we get started, do you mind if I start an audio recording?

1. To start off, could you tell me about your background?

Prompts:

   a. Educational background
   b. Current role in the university

I would like to understand the university's perspectives on sustainable development.

2. What informs or influences the university goals, values and culture?

Prompt:

   a. National policies and culture
   b. Labor markets, industry demands

3. How does sustainable development fit with the university goals, values and culture?
   a. Where is this seen?
   b. Why is it so?

4. How is the university vision communicated to departments?

Prompts:

   a. How is it reflected in the engineering curriculum?
   b. How is it reflected in faculty career/promotion paths?
   c. What are the biggest challenges and/or criticisms?
   d. What is working well?
   e. What are areas of improvement?

Now, I want to understand the departmental and institutional culture.

5. In what ways does university administration/institution support faculty including the SDGs into courses, if they know?
   a. How does the university view the integration?
   b. How are they rewarded, supported, and/or aligned with department/institution vision?

Now, I want to understand the external influences on the departmental and institutional culture.

6. What expectations do the engineering workplaces in the country have of their young hires?
7. How does the country/state value efforts towards sustainable development?

8. Is there anything else you would like to add about integrating the SDGs into your teaching?