Exploring Engineering Faculty Experiences and Networks in Integrating Ethics Education: Insights from a University-Wide Curriculum Reform

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ABSTRACT

In today's globalized and technology-driven landscape, engineers wield unprecedented influence. As a response to calls from engineering accrediting and professional organizations, engineering educators have begun to further emphasize the importance of ethical decision-making within the curriculum. However, despite numerous attempts to integrate ethics, there remains a lack of consensus on effective strategies, particularly for larger-scale initiatives.

This research, utilizing Lattuca and Stark's (2009) Academic Plan model, explores the Pathways curriculum reform at Virginia Tech, a university-wide initiative aimed at integrating intercultural awareness and ethical reasoning across general education courses. Through a case study methodology, semi-structured interviews were conducted with 12 faculty in the College of Engineering. Participants shared insights on the barriers encountered, resources utilized, and perceptions of ethical culture within their various academic environments. Additionally, participants described their network interactions within and beyond the curriculum reform initiative. Findings suggest faculty leverage existing networks during curriculum reform, with identified barriers categorized as influence-driven and resource-driven. Integrating these insights into the Academic Plan model offers a nuanced, process-oriented understanding of curricular change.

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GENERAL AUDIENCE ABSTRACT

In today's globalized and technology-driven landscape, engineers wield unprecedented influence. As a response to calls from engineering accrediting and professional organizations, engineering educators have begun to further emphasize the importance of ethical decision-making within the curriculum. However, despite numerous attempts to integrate ethics, there remains a lack of consensus on effective strategies, particularly for larger-scale initiatives.

This research explores the Pathways curriculum reform at Virginia Tech, a university-wide initiative aimed at integrating intercultural awareness and ethical reasoning across general education courses. To understand faculty experiences related to the curriculum reform, interviews were conducted with 12 faculty in the College of Engineering. Participants shared insights on the barriers encountered, resources utilized, and perceptions of ethical culture within their various academic environments. Additionally, participants described their personal collaborations within and beyond the curriculum reform initiative. Findings suggest faculty leverage existing networks during curriculum reform, with identified barriers categorized as influence-driven and resource-driven. By integrating these insights into one connected framework, we might be able to better understand and navigate the barriers associated with curriculum reforms.

Dedication

This study is dedicated to struggling graduate students. You have people who care about you and your success. Keep persisting, You can make it.

Acknowledgements

Over the past seven years, there have been countless individuals who have helped me on my journey to complete my dissertation. Starting with the most pivotal, I'd like to first thank Dr. Diana Bairaktarova for her immeasurable support throughout this journey. She has taken on many hats in my time in the EngE program, serving as an advisor, mentor, collaborator, and coach throughout my time here. It was only thanks to her patience, belief in me as a researcher and individual, and support that I was able to graduate from this program. Even in times when I gave up on myself, she never did, and will forever remain a part of my research family. She is my role model as a researcher and a person, creating community wherever she goes. If she had been anybody else, I doubtless would have given up and moved on years ago, and I will never be able to thank her enough for her continued belief in me over the past seven years.

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community and examining the impact of education and education research. Thank you for the incredibly formative opportunity, inciting my passion for social network analysis and ensuring my goal for my future work will have a tangible impact on the engineering education community. Also thank you to the students I worked with on the project, Dr. Hao Wang, Hesam Hosseinpour, and Kojo Akrong, who served as some of my first collaborators.

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Chapter I: Introduction

1.1 Introduction

In an increasingly global and technologically centric world, engineers have a broader and larger impact than ever before. Engineering's significant impact can be emphasized by recent events such as the Surfside condominium collapse and the Boeing 737 max crash (J. Herkert et al., 2020) or ongoing discussions on the ethical implications of self-driving cars (Borenstein et al., 2017) and ChatGPT (Qadir, 2023). With the amplified impact of technology, it is critical to take into account the ethical implications of engineers' actions and the ethics education of engineers in training. To emphasize their focus on the importance of ethics in the engineering curriculum, organizations such as the National Society for Professional Engineers (NSPE) and the National Academy of Engineers (NAE) have taken it upon their responsibility to create codes of ethics that outline the engineer's duty to conduct the profession in an honorable, responsible, ethical, and lawful manner to safeguard the public (NSPE, 2019; NAE, 2022). Similarly, to prepare future engineers to practice the profession ethically, accredited agencies such as ABET have integrated language requiring engineering programs to meet ethics-related educational outcomes (ABET, 2023).

While every engineering governing body recognizes the importance of engineering ethics education, there is a lack of consensus among engineering educators on 'what' should be taught in engineering ethics education (J. R. Herkert, 2005; National Academy of Engineering, 2016; Hess & Fore, 2018; McAninch, 2023). One of the primary debates is around whether ethics should be taught as microethics or macroethics. Microethics refers to engineers acting as individuals, and specifically the individual level of ethical decision making, focusing on personal values and behaviors to refine moral judgement (Kidder, 2009; Basart & Serra, 2013; Rachels & Rachels,

2023). On the other hand, macroethics pertains to the broader cultural, societal, and global responsibilities of the engineering profession, examining the ethical principles that guide institutions, organizations, and disciplines (Singer, 2011; Barry & Herkert, 2014). While microethics is seen as the predominant theoretical approach in the engineering ethics education discipline (Colby & Sullivan, 2008; Martin, Conlon, et al., 2021), scholars are vying for the integration of macroethics into the curriculum to prepare students to consider the impacts of their work in a more global context (J. R. Herkert, 2005; Bielefeldt et al., 2019). Recently, researchers have begun to argue for the integration of both macro- and microethics within the classroom but there no comprehensive framework for how to do so (J. R. Herkert, 2005; Schiff et al., 2021; McAninch, 2023).

Similarly, there is also a lack of consensus on how ethics should be implemented into an engineering curriculum. Traditionally, ethics has been incorporated into first year and capstone courses (Newberry, 2004; J. R. Herkert, 2006). However, methods for integrating ethics into the more technical middle years of engineering programs have also been discussed, such as through microinsertions, the goal being to teach ethics without disrupting the general structure of a course (M. Davis, 2016). Building off microinsertions, the ethics across the curriculum model (EAC) encourages faculty to collaborate to create an ethics curriculum that builds on itself over a series of courses or years, such as through the repeated use of microinsertions (J. R. Herkert, 2000; Cruz & Frey, 2003; M. Davis, 2006). The lack of consensus on how best to implement ethics into the engineering curriculum has led to a plethora of pedagogical strategies being utilized across universities (Colby & Sullivan, 2008; National Academy of Engineering, 2016; Hess & Fore, 2018).

In addition to the lack of consensus on 'what' should be taught and 'how' ethics should be incorporated into the engineering curriculum, there is a major gap in the literature that examines curriculum reforms with broader scopes (Feola et al., 2023). Specifically, there is a lack research that tracks change initiatives that take occur over multiple years. Further there is even less literature on initiatives that take place across entire colleges and universities. In their examination of 25 exemplar education activities and programs infusing ethics into the engineering curriculum, the National Academy of Engineering highlights only 5 programs that take a multi-course approach to engineering ethics education (National Academy of Engineering, 2016). Similarly, in their systematic literature review of US engineering ethics interventions, Hess & Fore (2018) found that only 1 of the 26 interventions could be classified as across the curriculum. Even when publications were associated with institutional as opposed to course-level change, Feola et al. (2023) found that these publications were still relatively narrow in scope, focusing on barriers to change, course level changes (Herman et al., 2018), or individual faculty perceptions (Lund & Stains, 2015; Shadle et al., 2017). Further examination in current literature reveals that there is a gap in comprehensively examining complex institutional change strategies and how diverse approaches can effectively overcome barriers to facilitate transformative change.

1.2 Purpose of Study / Research Questions

The purpose of this dissertation study is to examine the process of a university-wide change initiative to include ethical reasoning and intercultural/global awareness. Specifically, the curriculum reform is examined from the perspective of the College of Engineering faculty and administrators responsible for the creation and revision of courses that incorporated ethics. Additionally, this study also examines the overarching curriculum reform from a broader

perspective by investigating the personal networks of the most directly involved from the reform faculty and administrators. The following research questions guide the study:

Q1. What are the experiences of engineering faculty in developing courses with ethics components?

Q1.1. Pertaining to collaboration?

Q1.2. Pertaining to barriers and challenges?

Q1.3. Pertaining to faculty learning?

Q2. What are the personal networks of engineering faculty who develop courses with ethics components?

Q2.1. Curriculum Reform Networks?

Q2.2. Teaching Networks?

Q2.3. Research Networks?

Q2.4. Advise/Mentorship Networks?

1.3 Overview of Dissertation

In this chapter of the dissertation, the motivation and introduction to the study was discussed. Chapter 2 describes the relevant literature that pertains to engineering ethics education, change initiatives in STEM education, barriers to curriculum reforms, incentives, and resources to overcome curriculum reform barriers, and how social network analysis is used to investigate curriculum reform. Further, Chapter 2 describes theoretical frameworks used to examine curriculum reform in higher education, including the Academic Plan (Lattuca & Stark, 2009), the Comprehensive Model of Influences on Student Learning (Terenzini & Reason, 2005), and the Four Categories of Change Strategies (Borrego & Henderson, 2014), of which the former was used to guide the overarching study. Chapter 3 contains the research methodology of the dissertation,

including the research design, how the Academic Plan framework informs the study, the data collection methods, context of the study, participants, and data analysis methods. Chapter 4 includes the qualitative results from semi-structured interviews, including barriers that faced through the implementation of the revised curriculum, faculty perspectives on their institutional organizations, the incentives and resources provided to faculty throughout the reform process, and how faculty learned the necessary knowledge and competencies to revise their courses. Chapter 4 also includes the descriptive statistics of the participants personal networks, including teaching, research, mentorship, advising and curriculum reform networks. Chapter 5 discusses the findings, starting with a section on how the results fit into the Academic Plan framework, followed by a discussion on how the findings of this case study compare with other current literature. Additionally, I offer implications for research and practice on various stakeholder groups, including faculty, administrators, organizational change agencies, and academic institutions. I also provide the limitations of the study. Finally, Chapter 6 concludes the dissertation by summarizing the primary learnings and future directions for research that stem from this dissertation.

Chapter 2 – Literature Review

In response to the evolving landscape of higher education and the increasing demand for ethical considerations within professional fields, universities worldwide are undergoing significant curriculum reforms. These reforms often aim to integrate ethics components into various courses, particularly within disciplines like engineering where ethical decision-making holds paramount importance. The present dissertation delves into the experiences of faculty members engaged in developing courses with ethics components, within the context of university-wide curriculum reform. Specifically, this literature review provides a comprehensive examination of pertinent topics, including engineering ethics education, theories of change in higher education, barriers to curriculum reform, strategies for overcoming these barriers, and the application of social network analysis to understand faculty interactions and collaborations in this domain.

2.1 Engineering Ethics Education in the Classroom

Both profession oriented organizations such as the National Academy of Engineering (NAE) and Accreditation Board for Engineering and Technology (ABET) as well as discipline focused organizations such as the American Society of Mechanical Engineers (ASME) and the Institute of Electrical and Electronics Engineers (IEEE) emphasize the importance of engineering ethics education. Organizations such as these emphasize the importance of ethics through the language of their mission statements, accreditation criteria, and Principles and Practice of Engineering (PE) exam questions (National Academy of Engineering, 2004; IEEE - IEEE Code of Ethics, n.d.; ASME Code of Ethics of Engineers, 2012; ABET, 2023). Research indicates that professional engineers who received public welfare responsibility training in an engineering classroom, were more likely to consider the ethical responsibilities of their work, recognize unethical practices, and indicated a higher willingness to blow the whistle when compared to their

professional counterparts who had not public welfare training. Additionally, compared to public welfare training in the workplace or other areas of the university, training in an engineering classroom indicated higher levels of engineering professional responsibility (Cech & Finelli, 2024). While the importance of engineering professional responsibility and ethics training within the engineering curriculum cannot be understated, at the course level, there is still a lot of discourse on how ethics should be implemented.

Ethics is a broad area and can be applied to the engineering discipline in a plethora of ways. One of the prominent discussions amongst engineering ethics education researchers is between the use of microethics and macroethics (Barry & Herkert, 2014; McAninch, 2023). Microethics concerns the individual ethical decision-making of engineers, while macroethics refers to engineers' responsibility in a broader, societal context (Herkert, 2005). More specifically, areas such the ethical codes (M. Davis, 2016), responsible conduct of research (May & Luth, 2013), ethical theories (Bouville, 2008), academic honesty (Hutton, 2006; Harding et al., 2012), social justice (Riley & Lambrinidou, 2015), empathy (Hess & Fila, 2016; Walther et al., 2017; Hess et al., 2021), care ethics (Campbell et al., 2012), and moral emotions (Higgs et al., 2020; De Buck & Pauwels, 2021; Kotluk & Tormey, 2023) have all been used to great effect in the engineering context. However, in the engineering curriculum where technical content acts as a 'black hole' (p. 348) for instructional time, there is often not room to fit all ethics content, and discerning what works best for a course's situated context is a difficult task (Newberry, 2004).

The most common delivery of engineering ethics instruction is using case studies, which are either short stories of fictional or historical events, often revolving around the decision-making of an organization or individual (J. R. Herkert, 2006; J. Herkert et al., 2020). Students then respond to questions, individually, in groups, or as a class, to discuss the nuances of the ethical dilemma

the agents in the stories faced (Newberry, 2004; J. R. Herkert, 2006; Harding et al., 2007). An objective of this pedagogy is to have students think through realistic problems and come to a plan of action through collaborative perspective taking. Roleplaying (R. H. Prince, 2006; Doorn & Kroesen, 2013) and games (Lloyd & Van De Poel, 2008; Streiner et al., 2021) are among the other pedagogies commonly employed by ethics education faculty across disciplines. Games like those described in Sadowski et al. (2013) are designed to engage students with ethical quandaries through the lens of reason rather than rules. Role play, like case studies, allows students to examine a moral dilemma from another's perspective (Huff & Frey, 2005). However, by roleplaying as another individual, students may take on a self-oriented approach as opposed to an other-oriented approach (M. J. Prince & Felder, 2006). By taking on a self-oriented approach, students can imagine how they would act or feel if they were the person in the story, as opposed to simply imagining how that person might feel (Hess et al., 2017). Reminiscent of the content in engineering discussion, there are a plethora of pedagogies that have been utilized in the classroom, each with their own strengths and weaknesses, without consensus on when specific pedagogies are the most appropriate.

2.2 Engineering Ethics Education in the Curriculum

Taking a step back from the engineering course, there is ongoing discussion on how to include ethics in the larger engineering curriculum. Multiple models for incorporating ethics into the engineering curriculum have been put into practice. The most common mode of instruction is creating a standalone course specifically focusing on ethics (Hess & Fore, 2018). Standalone courses have the benefit of being able to dive deep into professional ethics and can both remain focused in the courses purposes while also covering a wide range of topics pertaining to engineering ethics (Pierrakos et al., 2019). While successful at smaller institutions, there is a high staffing cost

associated with including a course dedicated to ethics within in an otherwise packed curriculum (J. R. Herkert, 2000; Sunderland, 2019). These types of courses also subconsciously marginalize and compartmentalize ethics when separating it from the more technical content (Newberry, 2004; Lönngren, 2021). Similar issues have been seen in writing-intensive courses (Paretti et al., 2023) where connecting the course to the rest of the curriculum can be difficult.

Another method for incorporating ethics into the engineering curriculum that puts less burden on individual courses within a curriculum is to implement an *ethics across the curriculum* (EAC) model. In this model, ethics instruction takes place over multiple years and across multiple courses, often in the form of microinsertions or through individual modules within a course (J. R. Herkert, 2000; M. Davis, 2006; Hess & Fore, 2018). One of the arguments for this model is that ethics is present in all engineering work. Structuring ethics across multiple courses allows for the content, and therefore the understanding of ethics and morals, to be developed over time (Cruz & Frey, 2003; Mitcham & Englehardt, 2019). However, there are also many issues with this model. Firstly, not all engineering faculty feel prepared to teach engineering ethics (Hayward et al., 2016). Another issue is that it requires buy-in of ethics instruction from multiple instructors across a department. There is a lack of uniformity across faculty perceptions towards ethics in the engineering curriculum. Additional time is also needed in order to align material across courses. Both Davis (2006) and Hess and Fore (2018) discuss the benefits and deficiencies of each model. When using microinsertions, as in an ethics across the curriculum model, Davis (2006) acknowledges that the method is unlikely to produce engineering ethics experts as students may not be able to deeply engage with ethical content. Despite the support from engineering ethics education researchers' support for ethics across the curriculum (Cruz & Frey, 2003; Mitcham & Englehardt, 2019), it remains an underutilized model among engineering ethics curricula.

Hess and Fore (2018) highlight the underutilization of the across the curriculum model in their systematic literature review of US engineering ethics pedagogical interventions. Of the 26 interventions the authors examined, the authors only considered one of the interventions to be across the curriculum. Additionally, there is still not an agreement on the best mode of integration in isolated courses either. In the aforementioned study, 13 of the interventions integrated ethics into existing engineering courses, while 10 described stand-alone courses. The lack of research that examines the ethics across the curriculum model was also noted by the National Academy of Engineering. In their examination of exemplary higher education engineering ethics programs ethics implementation varied in size, scope, and context. The report highlights courses at both the undergraduate and graduate level as well as at multiyear programs that implement ethics. However, of the 25 examples that are highlighted, only five are multi-year programs (National Academy of Engineering, 2016).

2.3 Theories of Change in Higher Education

As engineering educators explore diverse pedagogical approaches to effectively teach ethics, it becomes imperative to seamlessly integrate ethical considerations into the engineering curriculum. Scholars have examined robust theories of change to determine what pedagogies and curriculum models are the most appropriate for their institution to improve student learning. In the following section, I present several theoretical frameworks that address change in higher education:

The Academic Plan in a Sociocultural Context: This model highlights the iterative nature of the educational reform process. The authors outline various internal and external influences that impact the educational environment. The framework offers three pathways by which the academic plan can be modified (Lattuca & Stark, 2009). Pathways A and B outline the process of evaluating and adjusting for an academic plan and the educational environment,

respectively. Pathway C suggests that the results of the academic plan may alter internal and external audiences' perceptions influences of a curriculum.

Diffusion of Innovations: This model outlines the process of technological and pedagogical adoption in higher education environments. Rogers describes how information is communicated within a social system, highlighting the stage of the innovation decision process and the choice that individuals make to adopt or reject a new system (Rogers, 2003).

Comprehensive Model of Influences on Student Learning and Persistence: This model was created to explore methods to improve student retention and learning in higher education, especially in the first year of college. Specifically, it examines how precollege experiences, university's organizational environment, and individual's experiences affect student learning and persistence. The model emphasizes the compounding influences that organizations, faculty and peers can have on students' college experiences (Reason et al., 2006).

Four Categories of Change Strategies: This model was created due to the lack of theories that emphasized change strategies. It outlines the importance of the aspect of the system that is being changed (individuals or environments and structures) and whether the intended outcome of the change is known in advance (prescribed or emergent). The two dichotomies are combined to create four categories of change, which are each the filled with change strategies and the role of the change agent (Borrego & Henderson, 2014).

Each of these four frameworks offers a unique perspective on the various influences of curricular change. Rogers (2003) diffusion of innovation framework examines the importance of interpersonal connections in propagating change initiative. The framework largely focuses on the

individual, failing to discuss the impact of broader organizational influences that may impact the adoption of pedagogical techniques. In contrast to this, Reason and colleagues (2006) framework examines a number of organization level influences that impact student's college experiences, but primarily emphasizes student experiences, examining the processes of faculty development and institutional influences with less granularity. Despite frameworks such as Borrego and Henderson's (2014) outlining numerous change strategies, various barriers to curriculum reform continue to prevent the ubiquitous implementation of ethics education across the engineering curriculum. I chose the Academic Plan in Sociocultural Context framework to frame my study, due to its appropriateness for studying a university-wide curriculum reform, including the inclusion of ethics in the general education curriculum. The framework lends itself to examining curriculum-wide initiatives given its potential to consider the holistic, comprehensive, socially oriented, and adaptable aspects of the curriculum reform in higher education. Additionally, other authors, such as Katz & Knight (2017) and Polmear (2019) have used the Academic Plan to examine faculty perspectives on ethics within the engineering curriculum. I discuss those ways in more detail below and in the study's theoretical framework section in Chapter 3.

2.4 Barriers to Curriculum Reform

In their framework for the Academic Plan in Sociocultural Context, Lattuca and Stark (2009) outline curriculum reform as an iterative process. Outlining this process, various groups and organizations influence the educational environment, the educational process happens, and the outcomes of the process are evaluated both by those in charge of the educational environment and those who hold influence over it. When there are differences between these two groups, or among those who hold influence, barriers to educational reform arise (Lattuca & Stark, 2009).

In practice organizational differences can manifest in the curriculum as disagreements on content, course sequence, instructional practices, and a lack of organizational support for faculty professional development. An unsupportive culture is a known issue in the engineering ethics education community of practice, partially due to the community of engineering educators who Newberry (2004) describes as "products of the admittedly ethics-deficient undergraduate" and "ethics-devoid graduate" (pg. 348) engineering educational systems (Lönngren, 2021). Barriers that originate from a disconnect between groups with or across higher education organizations may stem from a lack of trust (Greaves & Sorenson, 1999; Polmear et al., 2022), siloed engineering departments (Wankat, 2011), and differing engineering cultures (Beever et al., 2021).

When attempting to shift the culture of a department, college, or university with a change initiative, it is important to not think solely about the culture but of the individuals, faculty networks, and departments that make up the unit of change (Lattuca & Stark, 2009). A major barrier to change initiatives is that oftentimes the same incentives will not motivate all faculty to change. As in the case of Fisher et al. (2019), even within departments, there were subgroups of faculty who simply did not associate with each other regarding teaching. If these groups differ in their educational goals, one solution or incentive may not prove enough to induce a full curricular shift. Because of the various organizational goals that exist in higher education, it is important to create faculty awareness of the surrounding university environment, which can help faculty see the importance of an initiative, even if it does not exactly align with their goals (Ralph & Stubbs, 2014). Regarding engagement in teaching ethics and social impact, Polmear et al. (2020), found that faculty members' personal experiences, beliefs, and interests variable motivate their engagement with engineering ethics and societal impacts education which may encourage or inhibit the diffusion of pedagogical change (Rogers, 2003; Polmear et al., 2020).

When engineering professional associations and accreditation bodies attempt to exert influence over the engineering curriculum, it is typically done in one of two ways. The first can only be used by organizations that exert some sort of mandate over the academic plan, which is through policy or incentives. Policy is used to enforce, whereas incentives are used to motivate. The most ubiquitous policy that influences the engineering curriculum is ABET accreditation, which mandates that certain requirements in academic rigor must be met to be an ABET accredited degree-granting program (ABET, 2023). Policy may originate also from a university's general education curriculum, which requires a certain number of credits of an engineering degree to be cross-disciplinary. Incentives often come in the form of promotion and tenure practices (Armstrong, 2014), awards for exemplary teaching practices (Fischer et al., 2019), and financial incentives to be used for educational development (Wieman et al., 2010). While incentives can be a powerful tool for persuading faculty to join a pedagogical reform initiative, they are only as successful if they are valued as heavily as other research-focused incentives (Brownell & Tanner, 2012).

Any sort of shift in higher education, whether pedagogical or cultural, takes resources, which may come in many forms. In a pedagogical shift, instructional faculty may not be experts in a given discipline (i.e. engineering faculty incorporating ethics) which takes time and energy from their part to learn. Brownell and Tanner (2012) claim that insufficient training is one of the three biggest barriers to promoting pedagogical change, specifically that faculty felt they were ill-equipped to teach a proposed revised curriculum. Then comes the issue of requiring time to train faculty, which is a resource that faculty do not have in droves (Davis & Jacobsen, 2014). A lack of time does not solely exist as a barrier in course revision, it also exists within the curriculum itself. Newberry (2004) describes the technical engineering curriculum as a 'black hole whole

gravitational pull inexorably absorbs the students' time and attention' (pg. 348). While researchers such as Michel Davis (2006) have discussed the idea of incorporating ethics into technical courses via 'micro-insertions' to minimize curricular disruption, the issue of time remains.

2.4 Overcoming Barriers to Curriculum Reform

To overcome many of the barriers to curriculum reform, incentives and resources are required to learn the necessary competencies required of a curriculum reform when gaps in knowledge exist. This is especially the case when there is a lack of faculty experience or knowledge, which is one of the prevalent barriers to engineering faculty adopting ethics into their curriculum (Henderson et al., 2011; Brownell & Tanner, 2012, p. 20; Bawaneh et al., 2020). To illustrate the numerous methods by which faculty develop their curricula and undergo professional development, I created two sets of dichotomies: formal vs informal learning and individual vs community learning.

I first delineated across levels of faculty involvement within a change, specifically examining individual and community learning. This choice was made to enable change agents to understand who is involved within the change process and to highlight the importance of prior connections in the diffusion of information and pedagogies. In their framework outlining eight change strategies, Borrego and Henderson (2014) describe the importance of both informal and formal communities. I expanded on this delineation to examine the importance of both formal and informal learning processes in faculty professional development, both in formal and informal settings (Decius et al., 2022; Jackson, 2024). By examining this dichotomy, change agents may better understand when formal resources provided by a change initiative are being utilized, or when faculty are leveraging their own informal resources, whether on their own or through their connections. Figure 1 delineates the two dichotomies I outline above along with various change

strategies through which faculty develop pedagogies or disciplinary knowledge to overcome barriers to curriculum reform.

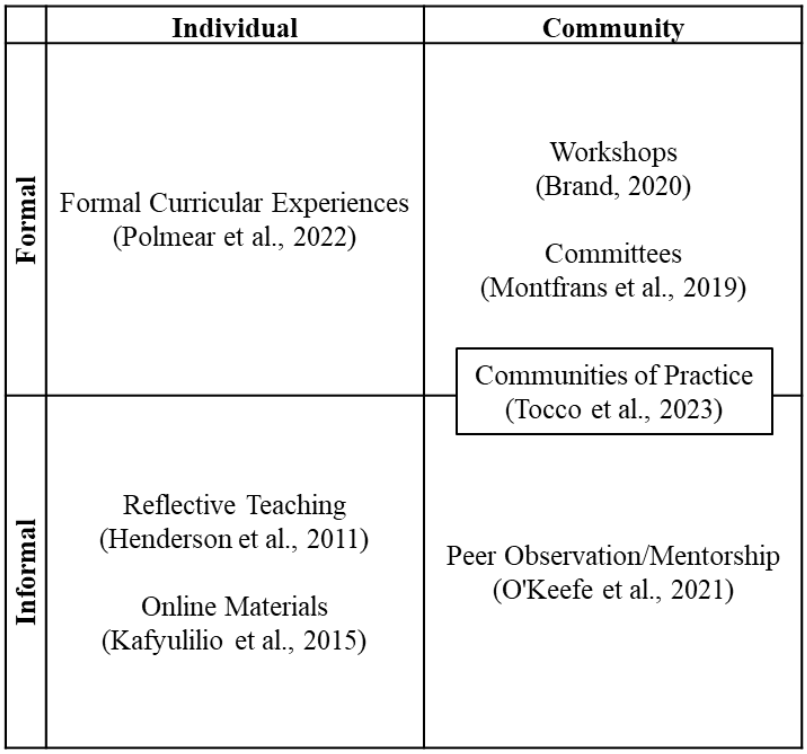

Figure 1. Faculty learning through the lenses of formality and group dynamics

2.4.1 Formal and Informal Learning

The formal learning process for faculty occurs when a facilitator guides and evaluates faculty learning objectives (Barrett, 2014). Examples of a formal learning process may include formal curricular experiences, conference lectures, workshops, and seminars (Diery et al., 2020). Brand (2020) created workshops for teachers to participate in activities for multiple days over a summer to bring together educators to learn about inquiry-based strategies for teaching, active learning, and hybrid instructional approaches. Similarly, Van Montfrans and colleagues (2019) lead discussions and workshops to support faculty with "scaffolded community discussions" to help control the conversations around continued learning . While formal learning can provide a

structured environment for faculty learning, they often require a larger time commitment than informal learning.

The informal learning process occurs when faculty acquire knowledge through self-directed learning, whether with a mentor or independently (Jackson, 2024). The process can include peer mentorship, informal conversations, storytelling, and communities of practice (Decius et al., 2022). While communities of practice can be formal and centered around a discipline (Ward et al., 2021), community can also be created through more informal experiences. These informal conversations can also consist of mentoring, in which a senior or more experienced faculty guide less experienced faculty through the ins and outs of the trade (Baker et al., 2020). As an example, O'Keefe and colleagues (2021) found that cross-institutional peer observation of teaching provided an opportunity for participating faculty to gain new perspective on teaching practices.

2.4.2 Individual and Community Learning

Similar to how Bary and Rees (2006) describe self-information and experiential learning, I define individual learning as reflecting on prior experiences and finding information to improve one's teaching. Tucker and colleagues (2014) found that those who engaged with reflective pedagogies after service-learning developed as 'professional engineers'. Similarly, reflective teaching empowers educators to use their own knowledge, experiences, and skills to improve their own teaching and develop as professionals (Henderson et al., 2011). However, there are barriers that inhibit faculty from being reflective in their own practices. This is in part due to research-oriented institutions incentivizing grants and publications over teaching for tenure and promotion (Bawaneh et al., 2020) and due to the lack of formal educational training that many faculty receive (Newberry, 2004). Exemplary course materials from similarly taught courses can help to minimize

the barriers in transitioning to a new pedagogy or technology. To prepare faculty to teach collaborative design through technology-enhanced lessons, scholars provided exemplary lessons and online materials to serve as a baseline for faculty to develop their own courses (Kafyulilo et al., 2015).

While scholarly teaching is often seen as an individual endeavor, faculty learning communities enable individual faculty to learn from each other (Borrego & Henderson, 2014). Community learning refers to the group of peers in academia, students, or instructors, leveraging their combined resources and learning from each other (Wenger & Snyder, 2000). Peer mentoring and workshops are examples of faculty learning in communities. Series of workshops can also be implemented over the course of longer periods of time (Baxley et al., 1999; Hayward & Laursen, 2018). Learning communities also offer a route by which faculty can learn from others. As an example, Tocco and colleagues (2023) found that learning communities can encourage the use of pedagogical metacognition in higher education faculty through group discussions, monthly meetings, and metacognitive reflections.

Scholars have identified that there is a gap in the literature about institutional change concerning how a specific set of change strategies might overcome the barriers to curriculum reform (Wieman et al., 2013; Shadle et al., 2017). Additionally, there is a lack of understanding of how a given set of strategies work together synergistically within an institution's specific context (Feola et al., 2023). Current methods for evaluating the effectiveness for pedagogy-focused workshop and seminars can be tracked through surveys and interviews, but are unable to examine the importance of community dynamics and informal learning that faculty leverage within curriculum reform initiatives. Social network analysis offers a way to examine the importance of informal and formal communities through empirical methods.

2.5 Social Network Analysis

A network is a series of nodes and ties, which can be conceptualized as something akin to a crystal lattice made up of atoms and their connecting bonds. Nodes, also known as actors in human-centered research, can be used to represent individuals, literature citations, organizations, disciplines, and departments (Carolan, 2013). As each actor has characteristics associated with them, each node does as well. For example, faculty from prestigious institutions often have a predisposition for working with individuals from similarly rated institutions. If this happens at many levels of academia, creating clusters or 'small worlds' of faculty (Xian & Madhavan, 2014; Celis & Kim, 2018). This concept of like-minded entities clustering together is known as homophily and has been shown to stifle creativity in the context of research output (McPherson et al., 2001; Celis & Kim, 2018). In the same way that an actor can have attributes describing them, ties may also have attributes, which represent the strength and type of relationship of two actors within in a network. Ties might represent a behavior, a physical connection, association, evaluation, or formal relation between two people (Carolan, 2013). Together a series of nodes and ties build a network of people.

2.5.1 Social Networks in Higher Education

While the theoretical impetus for social network analysis in higher education change research is clear, examining how social networks have been previously utilized in higher education change literature may provide further grounding for this study. Social network analysis has been used extensively to study the structure of higher education, particularly at the faculty level (Durrington et al., 2000; Coburn et al., 2010). Faculty networks have been studied frequently in higher education largely due to the fact that faculty on average remain at institutions longer than

students. This happens for many reasons, faculty may be able to influence the culture of the institution more due to their longer tenure, the relatively obscure and individualized nature of teaching courses, and the higher autonomy of faculty in higher education. Coburn, Choi, and Mata (Coburn et al., 2010), in an examination of a district-based math reform, emphasized the importance of teachers' social networks as "an important part of the school improvement puzzle" (p. 60). They went on to describe that faculty members facilitate the transfer of knowledge regarding research, pedagogy, and organizational issues that other methodologies cannot fully grasp (Coburn et al., 2017). Social networks have been vital in learning how faculty members are influenced by their peers in adopting and developing new technologies and instructional practices for their classrooms, as they present a method of visually presenting the informal structure of higher education (Durrington et al., 2000; Coburn & Russell, 2008; Penuel et al., 2009; Spalter-Roth et al., 2010; Spillane et al., 2010). Networks have also been utilized in explaining how faculty knowledge and innovation transfer and flow throughout departments. Social, informal connections instill trust between colleagues, which can create buy-in to an otherwise unwanted institutional change. Interactions among faculty are a valuable but often overlooked commodity of higher education (Moolenaar & Sleegers, 2010).

Social networks have been utilized to study communities of practice (Herbert et al., 2014), perceptions of sustainability (Wright, 2010), and transformative change (Morphew, 2009). Since higher education is a complex system, it stands to reason that researchers would want to break down higher education into component parts. Historically, this has been done by studying individuals, whether through the lens of faculty, students, or administrators (Henderson et al., 2011; Biancani & Mcfarland, 2014). Social networks not only analyze the individuals within the complex university network, but also make sense of the connections between them (Pifer, 2011).

Faculty, staff, and administration are all responsible for ensuring that change in higher education is sustained (Cameron, 2017). Researchers have studied faculty members more frequently than students when utilizing social network analysis. In a meta-analysis of social networks in higher education conducted by Biancani and McFarland (2014) of the 171 networks that the authors examined, 117 of the networks concerned faculty. Faculty are studied most frequently in change literature because they remain at institutions longer than either students or administrators (Kezar, 2014). Networks in higher education have also been studied to understand the diffusion of best pedagogical practices and new technologies for the classroom across faculty members, finding that one's colleagues play a large role in the adoption of these practices (Durrington et al., 2000; Parker & Quinsee, 2014).

2.5.2 Egocentric Network Analysis and Learning

There is a surprising lack of social network change literature concerning ethics education, especially when considering the various national and disciplinary institutions that place such a heavy emphasis on integrating ethics education into the engineering curriculum. Both Borrego and Henderson (2014) and Kezar (2014) have each outlined that social networks have the potential to help researchers view pedagogical change initiatives in a structural manner, which may have implications in overcoming various barriers to change in higher education. Similarly, the social component in the development process is often ignored (Hadar & Brody, 2010).

However, egocentric networks have started being used to examine curriculum reform in higher education, even if in a limited capacity. Noben and colleagues (2022) have used SNA to examine the effects of teacher's networks in a professional development project. They found that more experienced faculty were more likely to collaborate with their peers (R. Cross et al., 2001); however, this study was limited to one department. Schreurs (2019) found that in vocational

schools, professionals tended to form homogeneous and dense networks. In their examination of faculty personal networks, researchers (Pataraia et al., 2014) found that faculty teaching networks were primarily discipline-specific and strongly localized, which may reduce innovation. While egocentric networks are beginning to be used to examine faculty learning, they are often limited in scope, often looking at one discipline or department. This study aims to fill the gap in the literature by examining the personal networks of engineering faculty across seven departments in the midst of an institutional educational reform.

Chapter 3 – Research Methods

The purpose of this dissertation is to investigate Pathways, a university-wide curriculum reform, within the College of Engineering (CoE). To provide an in-depth understanding of the curriculum reform, I examine engineering faculty experiences and personal networks through their involvement in the Pathways undergraduate curriculum reform at Virginia Tech. This case study is guided by the following research questions:

Q1. What are the experiences of engineering faculty in developing courses with ethics components?

Q1.1. Pertaining to collaboration?

Q1.2. Pertaining to barriers and challenges?

Q1.3. Pertaining to faculty learning?

Q2. What are the personal networks of engineering faculty who develop courses with ethics components?

Q2.1. Curriculum Reform Networks?

Q2.2. Teaching Networks?

Q2.3. Research Networks?

Q2.4. Advise/Mentorship Networks?

Across the College of Engineering, faculty and administrators involved with the Pathways curriculum reform at Virginia Tech have faced a breadth of experiences as they revised their courses. They have experienced various challenges and setbacks in incorporating ethical reasoning into the design and teaching of their respective courses. The Pathways faculty also are connected to other professionals at the institution who play a direct or indirect role in their experiences creating and revising their courses. To provide an in-depth picture of the curriculum reform in the

College of Engineering, I utilized an embedded, descriptive case study methodology. Now that I have outlined the research questions and the approach, I took in conducting my dissertation study, it is essential to delve into the foundational assumptions underpinning qualitative research methodologies.

3.1 Assumptions of Qualitative Research

Social constructivism as a worldview acknowledges that the individuals within the study will develop their own subjective meanings of their experiences (Berger & Luckmann, 1990). The worldview posits that individuals shape their own understanding of the world through interactions with others and both the historical and cultural context in which they exist (Vygotsky, 1962). A social constructivist worldview was utilized as the research aims to rely on the experiences of the participants to construct meaning of the situation being studied (Lincoln & Guba, 1985). Within a social constructivist framework, it is important for the researcher to be reflexive, acknowledging that they are an integral constructor of the social reality of the study (Gall et al., 1996).

3.2 Positionality Statement

Reflexivity and positionality are important components of the qualitative research process as a researcher's underlying epistemological and ontological assumptions, their beliefs and values, play a role in how research is conducted (Holmes, 2020). Reflexivity is the idea that a researcher's preconceived notions may influence their decisions and actions throughout qualitative research activities (Johnson et al., 2020). Similarly, positionality describes an individual's worldview and the role that plays throughout the process of qualitative research. Positionality influences the entire research process, from how it is conducted to how researchers interpret the outcomes and results (Rowe, 2014).

Both my undergraduate and graduate careers have been at Virginia Tech, the setting for this study. Additionally, I saw the impacts of unethical behavior on the part of students in both academic and extracurricular settings which in a way lead me to pursue a degree in engineering education and gain the skills and knowledge to conduct this study. Because of my formal teaching experiences and value on ethics, I believe that all faculty want the best for their students and conducted my interviews under the assumption that the changes they made to incorporate ethics were beneficial. I understand the similarities between myself and the participants, in having an undergraduate engineering degree, in some cases from the same university, and having taught ethics lessons to engineering students in higher education. I also understand the difference between myself and my participants, not having experience creating or redesigning an entire course curriculum, and not being a faculty member in a university, with the various responsibilities, influences, and work those entails. In view of my personal experiences and background discussed in this section, this dissertation study has been conducted with the express purpose of understanding the experiences of my participants and that their voices were emphasized in reporting the study findings.

3.3 Theoretical Framework

This study is informed primarily by Lattuca and Stark's Academic Plan in Sociocultural Context, shown in Figure 2. Lattuca and Stark propose a framework for the curriculum as an academic plan to understand the process of course planning. The authors' rationale for the framework was the lack of a comprehensive framework. Additionally, they saw both a curriculum and plan as something that is created through intentional and informed choices, is beholden to outside influences, and may have varying degrees of success. The framework can be adapted to a curriculum of any size, from a single lesson plan to an entire degree program. Within the Academic

Plan itself, the curriculum designer is responsible for aligning the content of the curriculum with the purpose and the sequence of it. Based on these aspects of the designed curriculum, the academic planner will consider the available resources to plan pedagogical strategies to teach learners and assessments and evaluations to ascertain how well students learned the content. This process is then iterated before the next instructional period to revise and improve the plan for the next cohort of students.

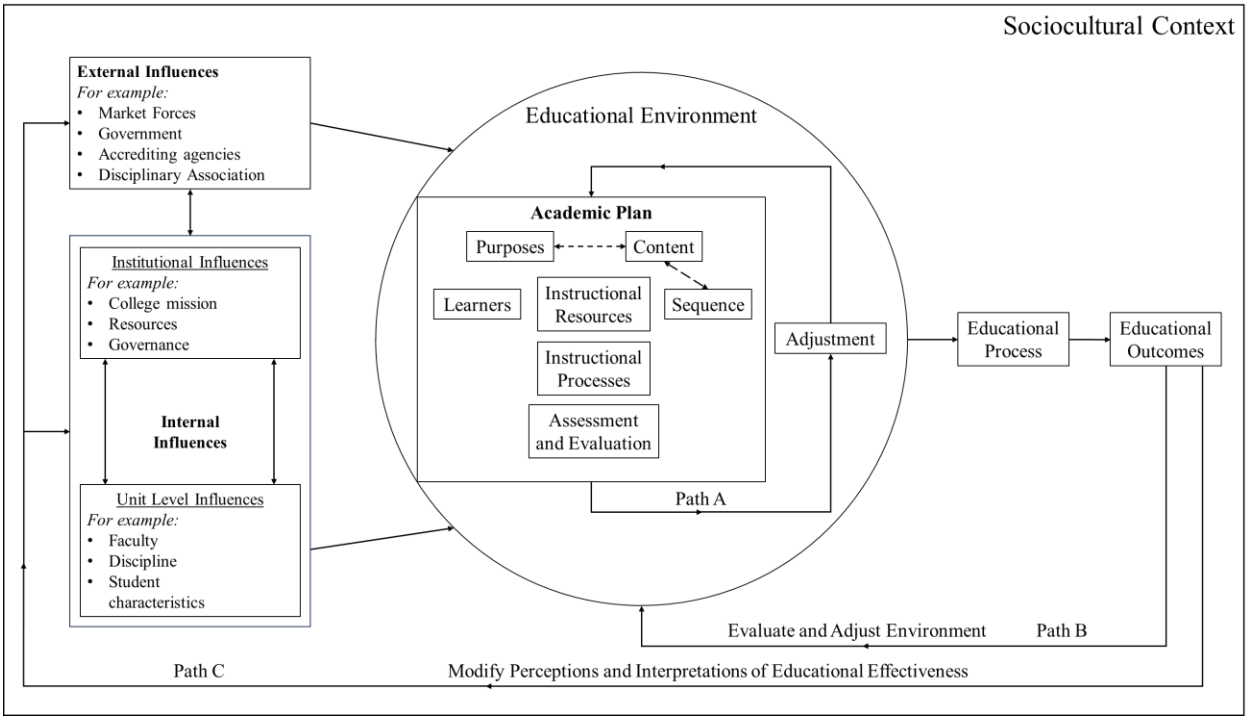

Figure 2. The Academic Plan adapted from Lattuca and Stark (2009)

The Academic Plan has been used in higher education to examine curricula and provide insight into revisional practices from a course-level to a program-level. An example of a course-level plan was constructed by Xu and Morris (2007) in their examination of the collaborative course development process for an online course. Through observation of team meetings and interviews with team members, researchers found that online course development was similar to

that of traditional courses in that content was the focus of the academic plan. As online course development practices were not as researched as traditional face-to-face instruction, there were disagreements between the faculty and the project coordinator concerning the pedagogical strategies employed in the course (Xu & Morris, 2007). Researchers have also utilized the framework to take a broader approach to academic planning, examining the implementation of programs such LGBTQ curricula (Linley & Nguyen, 2015), leadership in graduate programs (Freeman et al., 2016), and Education in Sustainable Development (Mahmud, 2017). Each of these groups of researchers used the Academic Plan framework as a tool to systematically plan, examine, and evaluate larger pedagogical and cultural initiatives.

The Academic Plan framework has also been used in engineering education research to examine faculty views of engineering ethics education. Katz and Knight (2017) have used it to examine faculty views of how engineering ethics should fit withing their engineering courses. Polmear (2019) has similarly used the framework to examine how personal and environmental influences impact faculty's views on ethics and societal impacts (ESI) education. Martin, Bombaerts, and Johri (2021) took an autoethnographic approach, by examining internal power relations affecting the use of engineering ethics within the engineering curriculum.

The above studies describe the use of The Academic Plan framework in examining curriculum reform at the program-level and within the engineering education discipline, which situates this research to utilize the framework. The reason The Academic Plan framework was chosen to guide this study is twofold. Firstly, one of the purposes of case studies is to illuminate a decision or set of decisions, and how they were implemented. The case study methodology aligns with this process-oriented nature of the Academic Plan framework. Second, case studies aim to

understand the multifaceted nature of a phenomenon, which aligns with the discussion of external and internal highlighted in the Academic Plan.

3.4 Research Design

3.4.1 Descriptive Single Case Study

A descriptive case study is described a phenomenon and the context in which it occurred (Baxter & Jack, 2008). It involves a detailed and comprehensive examination of a specific case, aiming to gain a deep understanding of the context, dynamics, and factors at play. Case studies are often used to explore complex phenomena, provide rich descriptions, and generate insights into real-world situations (Creswell, 2013). A case study methodology is also appropriate when there are not clear boundaries between the phenomena and the context of the study. In the context of this research, it would have been impossible to examine how faculty redesigned their courses without understanding the context of their home departments, the university, and the Pathways curriculum reform that was underway at the time (Yin, 2003; Baxter & Jack, 2008).

3.4.2 Context

Pathways is best described as the general education curriculum at Virginia Tech. Formerly known as the Curriculum for Liberal Education (CLE), the Pathways program began in 2018, but the process from converting from CLEs began over half a decade before. The Pathways program was Virginia Tech's response for calls to incorporate more advanced discourse and computational thinking across all curricula to prepare students for a more global workforce. The Pathways curriculum revision had multiple thrusts (1) to incorporate advanced discourse and (2) to incorporate computational thinking across all general education courses; (3) creation of new minors that fulfilled the general education learning objectives. Since the first implementation of

the Pathways courses in 2018, over 500 courses across the university and 32 courses and series of courses within the College of Engineering have been created or revised.

The most common reasoning for course creation was to meet the Advanced Discourse requirement, with 12 of the 32 courses meeting the requirements. As a newly created requirement for all graduating students at the University, the CoE initially tried to work with the English department to meet this requirement. However, after a disagreement of resource allocation, each department took to meeting the requirement themselves. Two of the departments continued their prior collaboration with the English department for a technical writing course, and 9 departments created their own course or series of courses to meet this requirement.

The second change that affected the CoE was the added requirement of Advanced Quantitative and Computational Thinking. The College of Engineering leveraged courses within the Math Department that were already required to meet the new Pathways requirement. However, Computer Science worked to revise 6 of their introductory and advanced programming courses to allow out-of-college students the opportunity to meet the requirement, 3 of which are a part of this study's sample.

The third most common type of courses were those created for new Pathways minors, which allowed students to meet a large set of their Pathways requirements while working towards a minor with a Capstone. There are 30 different minors that exist. The set of 6 courses within the CoE were spread across 5 departments and 5 different Pathways minors, 1 of which was a part of this study's sample.

Lastly, there were around 7 course series that did not fit to any larger pattern. Two of these courses were offered by the required introductory engineering education courses. Some were listed

as multidisciplinary technical electives for the college, while others appeared to be service courses for the university to meet other Pathways requirements.

Courses were created to meet the new Advanced Discourse requirement, the Advanced Quantitative and Computational Thinking requirement, or a Pathways minor. These 32 courses are spread out across 12 of the 13 departments in the College of Engineering (CoE), with Chemical Engineering containing zero Pathways courses on the low end and Computer Science and Engineering Education having 6 and 7 courses respectively. A breakdown of the rationale for the courses can be seen below in Table 1.

Table 1. Reason for creation of Pathways courses in the College of Engineering

Course Creation Reasoning	**in CoE**	**in Sample**
Advanced Discourse	12	6
Computational Thinking	7	3
Pathways Minor	6	1
Other	7	1
Total	32	11

Each of these changes in and of themselves would have presented a significant challenge for engineering departments at Virginia Tech to implement, with their already overloaded course schedule. However, in addition to the new requirements for each degree-granting program, every Pathways course now had to assess for one of two integrated components, either 'ethical reasoning' or 'intercultural and global awareness.' Of the 32 courses within the College of Engineering that were created or redesigned for the Pathways program, 31 of the courses chose the integrative component 'ethical reasoning.'

While some of the courses within the College of Engineering were created for Pathways, most were adapted from preexisting courses to fit the new program. The breakdown of new and revised courses can be seen below. In the case of Advanced Discourse, two series of courses contained both revised and new courses. In both cases, the senior capstone courses were revised while a new sophomore or junior-level course was created. One point of note is that while the Advanced Discourse and the Advanced Quantitative and Computational Thinking courses were primarily revised, the courses linked to Pathways were often new courses. A breakdown on the status of the Pathways courses at the time of inception can be found below in Table 2. In total, as a part of the Pathways curriculum change, over 500 courses across the University were created or revised to become listed as Pathways courses.

Table 2. Revised and New Pathways Courses in the College of Engineering

Course Creation Reasoning	Revised Courses	New Courses	Combined	Total
Advanced Discourse	8	2	2	12
Computational Thinking	5	2	0	7
Pathways Minor	2	4	0	6
Other	5	2	0	7
Total	20	10	2	32

3.4.3 Case

A single descriptive case study with multiple embedded units of analysis was used for the design of the study. A case study is chosen to study a case with clear boundaries (Creswell, 2013). In this study, the case is the Pathways curriculum reform within the College of Engineering at Virginia Tech. The embedded subunits of analysis were 12 instructors who created or revised courses for the Pathways university-wide curriculum reform. The rationale for the specific context

being chosen for a descriptive single case study is that it is a unique case (Yin, 2003). Specifically, university-wide curriculum reforms integrating ethics are not well documented in literature. The embedded approach was chosen as subunits can add "significant opportunities for extensive analysis" which can further the researcher's understanding of the case (Yin, 2003, p. 46). To facilitate the extensive analysis, the same data types were gathered across all twelve faculty, with each unit being analyzed individually and then collectively.

3.4.4 Participants

Virginia Tech is a large public Research 1 University in the Mid-Eastern United States. The university boasts roughly 29,000 undergraduate students and 2,000 instructional faculty. Within the university, there are seven colleges with their own departmental structure. In the College of Engineering at Virginia Tech there are nearly 9,000 undergraduate students and approximately 400 instructional faculty. Of the 400 faculty, approximately 35 teach Pathways designated courses with the integrative *ethical reasoning* concept. This subset of faculty will serve as the population for this research, as these faculty were the most involved with the Pathways curriculum changes within the College of Engineering that centered on ethics.

Participants were chosen for this case study via a combination of purposeful sampling methods. First, maximum variation sampling was employed to ensure that a broad range of engineering departments' perspectives were discussed (Miles et al., 2019). Second, during interviews, participants were asked if they had colleagues who also worked on the Pathways curriculum reform, either in their department or outside of it. The combination of the sample methods allowed for the maximum number of departments to be surveyed while also examining multiple perspectives from within a department when appropriate. Snowball sampling also aligns

with the goals of social network analysis to uncover the networks of participants (Perry et al., 2018d).

Participants of the study were from seven departments across the College of Engineering. The gender distribution of the sample as self-identified was 50% identifying as female and 50% identifying as male. While the interviews took place in 2022, participant time in academia and university position were determined based on the start of the Pathways curriculum reform initiative in 2018. Faculty that participated in the Pathways curriculum reform spent a wide range of time in academia. Multiple participants were hired for the explicit purpose of filling the Pathways courses for a given department, while in other cases, more experienced teaching faculty were given the opportunity to lead the curriculum redesign. Participant positions at the university also varied, with two administrators and ten teaching faculty. Faculty sample demographics can be seen in more detail below in Table 3. It should be noted that of the two Assistant Department Heads, each also had either research or teaching responsibilities, but as each indicated that their primary responsibilities were administrative, they were listed as Assistant Department Heads for the simplification of demographic characteristics.

Table 3. Faculty sample demographics

Demographic Categories	**Frequency**
Gender	
Male	6
Female	6
Time in Academia	
0-2	*3*
3-5	*4*
6-10	0
10+	5
University Position	
Assistant Department Head	2
Professor of Practice	6
Collegiate Professor	3
Adjunct Faculty	1
Total	12

Throughout the Results and Discussion in chapters 4 and 5 respectively, faculty that had positions under the denomination of collegiate associate/assistant professor, professor of practice, instructor, and adjunct faculty were considered teaching faculty. The collation was done because across all four roles, the primary responsibility of faculty was to teach. Collating faculty roles also aligns with goal of homophily in social network analysis, which is to examine the similarities of faculty, which in this case is in examining the tendency for teaching faculty to collaborate with other teaching faculty. To simplify the position demographics further, administrator positions were defined as positions with department head, director, or provost in their title. Positions with coordinator in the title were listed as staff.

3.4.5 Data Collection

Data for this study was collected from multiple sources, including institutional data about the courses within the Pathways program and semi-structured interviews with faculty. Institutional data were collected to identify which courses were a part of the Pathways program, and to identify

participants. Additionally, institutional data in the form of program check sheets were collected to triangulate program changes discussed by participants about the Pathways revision process. The archival data was used and compared to the transcripts from the faculty interviews, to focus the conversation of the courses and highlight potential discrepancies between the archived experiences and the lived experiences of the individual (Tracy, 2010).

Semi-structure interviews were chosen for this dissertation study as they align with the case study methodology which allow the participants to stray from the interview questions and more holistically describe their experiences (Creswell, 2013). The interviews were designed to investigate the experiences of engineering faculty undergoing course revisions during the Pathways program. The interviews aimed to encourage faculty to talk about their experiences with the general education revision process, with a focus on the integration of the ethical reasoning component of each course. A series of follow-up questions were asked depending on the faculty response but were scoped to focus on the various resources and mechanisms that inhibited and enabled faculty throughout the course revision process. The full protocol can be found in Appendix 1. Not every question on the protocol was asked to each participant due to the nature of semi-structured interviews. The interviews were conducted between March 2022 and July 2022. The twelve interviews ranged in length from 43 to 94 minutes with an average interview length of 71 minutes. Participants were not compensated for their participation in the study. Of the twelve interviews, eleven were conducted over Zoom, and one was conducted in person and audio recorded via a recording device. Interviews were transcribed and later cleaned with the online software OtterAI (2022) After cleaning, transcripts were deidentified via pseudonyms and sent to participants to check for the accuracy of the transcripts (Given, 2008). Deidentified transcripts were uploaded to the software AtlasTI (2023) for coding purposes.

3.4.6 Interview Protocol

The first group of questions discussed the experiences of the faculty in designing and teaching their Pathways courses. Specifically, questions were informed by build on other works to discuss the process of designing and evaluating the ethical reasoning component of the course (Lattuca & Stark, 2009), barriers and challenges of implementing ethical reasoning (Henderson & Dancy, 2007; Sturtevant & Wheeler, 2019), collaborations with other faculty (Fleming, 2014; Venance et al., 2014; Ma et al., 2019), and faculty learning (Besterfield-sacre et al., 2014; Gwynne-Evans & English, 2014; O'Meara et al., 2017) throughout the entire process of incorporating and teaching ethical reasoning in an engineering course. Examples of these questions from this section of the semi-interview include: *How have you incorporated ethical reasoning into the design of your course?* and *What institutional resources did you utilize in the development of the course, if any?*

After discussing how faculty implemented ethical reasoning into their curriculum and evaluated their assessments, the second group of questions broaden the discussion onto what faculty perceptions of the importance of ethical reasoning are in the Pathways program, the engineering curriculum, and their discipline, specifically. This series of questions is largely informed by the research of Holsapple et al. (2012) which introduces a conceptual framework for student's ethical development during college. The questions in the section asked about the importance and role of formal curricular experiences in the development of student's ethical reasoning. Examples of questions from this section include: *What would you say the culture of your department is towards developing ethical reasoning?* and *What role do you think formal courses play in developing students' ethical reasoning skills?*

The last section of the semi-structured interview contains questions regarding the faculty member's personal networks. An integral component of the Academic Plan framework is the recognition of various organizational and individual influences over the curriculum (Lattuca & Stark, 2009). Identifying faculty personal networks allowed me to more comprehensively understand the set of individuals who played were a part of the curriculum reform or had the potential to influence the participant across other personal networks. Questions concerning faculty connections are derived from other literature and discuss who the participant had conducted research with (Polmear et al., 2020), who they have taught with (Baker et al., 2017; Polmear et al., 2020), who they go to for advise (S. P. Borgatti & Cross, 2003), and who they see as a mentor (Lee & Bozeman, 2005; Alkaher & Avissar, 2018). Each of these connections were chosen as they have been shown to influence faculty perceptions of students' educational outcomes. Examples of questions from this section include: *Since the start of the Pathways program, who have you talked to about teaching a course?* and *since the start of the Pathways program, who have you talked to as a mentor/mentee?*

4.4.7 Data Analysis

4.4.7.1 Qualitative Data Analysis

During the semi-structured interviews, data was collected via a recording device. For the in-person interview, the recording software on a phone was used, while for the semi-structured interviews conducted online, the Zoom platform recorded the audio from each interview. The initial transcription was completed via the software OtterAI, and researchers listened through the interviews in multiple passes to complete the cleaning process. Analysis was conducted via the online qualitative coding software AtlasTI Web (2023). Data analysis was performed based on the six-step approach to qualitative data analysis and interpretation described by Creswell (2009).

The first round of data analysis was conducted via multiple passes of descriptive coding (Miles et al., 2019). For the first round of coding, each interview was analyzed separately (within units). Descriptive coding was used to summarize large passages of qualitative data. The generated codes were then used to inform the second round of data analysis which was conducted across all the interviews (across units). The second round of data analysis was conducted via pattern coding to condense the initial codes into a coherent set of themes.

The initial descriptive coding was completed across four passes of the data, a summary of which can be found in Table 4. An initial coding pass was completed to understand the general structure of the interviews, and to highlight discussion of the ethics implementation within the course and faculty roles at the university. The initial pass simplified future coding passes by being able to ignore large parts of the transcripts that were largely descriptive and helped apply "thick" description (Tracy, 2010) to the data analysis by providing context of the participants and the experiences surrounding quotes. A second pass of coding examined the Pathways design process of the participants. This round of coding examined the individuals most closely involved with the redesign aside from the interview participant and how those individuals interacted withing the surrounding sociocultural environment, and the changes that were made to the course. A third pass focused on faculty ethics learning and institutional resources/incentives. This round of coding examined the process by which faculty learned to incorporate ethics into their curriculum, whether via pressures from institutional units or faculty proactively seeking out resources. A fourth pass focused on perceived barriers and challenges to incorporating ethics into their curriculum. This round of coding examined challenges caused by a deficit of resources as well as barriers arising from value differences across organizational units and faculty perceptions of various organizational units on campus.

Table 4. Outline of Descriptive Coding Process

	Descriptive Coding Passes
1st Pass	Course Description, Ethics Implementation, Faculty Roles
2nd Pass	Pathways Design Process
3rd Pass	Faculty Learning, Resources/Incentives
4th Pass	Barriers/Challenges, Faculty Perceptions of Organizational Units

After the four passes for initial coding to segment the text into smaller chunks, pattern coding was conducted across all the themes established during the initial coding process. Pattern coding was chosen due to its appropriateness in examining multiple participants and for its ability to analyze across units (Miles et al., 2019). The constant comparison analysis was utilized to identify codes both inductively (emergently in the data) and deductively (a priori and looked for in the data) (Leech & Onwuegbuzie, 2007). Specially, influencing groups were coded a priori based on the groups identified in the guiding theoretical framework and in prior research (Lattuca & Stark, 2009; Polmear, 2019). The number of themes was largely dependent on the variance of codes within a theme. The 'Faculty Learning' theme included five sub-codes while the 'Barriers/Challenges' themes included nine sub-codes. A second round of pattern coding was conducted on the newly created themes under barriers/challenges to further delineate the themes.

3.4.7.2 Quantitative Data Analysis

The quantitative data for this study was analyzed using RStudio, E-Net, and UCINET (S. Borgatti P. et al., 2002; S. Borgatti P., 2006; RStudio Team, 2020). RStudio was used to calculate the average size of actors' networks for the whole network as well as for the seven categories of connected networks (curriculum reform, research, teaching, committees, administrative, mentorship, advice). E-net was used to calculate compositional measures, including the 1) frequency and percentage of alters' attributes and the 2) E-I index for homophily (Krackhardt &

Stern, 1988; S. Borgatti P., 2006). UCINET was used to calculate the frequency of parallel ties and visualize the whole network.

Compositional Measures. Egocentric networks focus on individuals and the connections of both them and their alters (Halgin & Borgatti, 2012). Compositional measures can either focus on the 1) alters attributes, 2) the connections between the ego and the alter (homophily), and 3) the connections between alters (heterophily). In this study, researchers examined the departmental affiliations and position. Departmental affiliation was differentiated into five categories: a) same department in same institution, b) different department but same college within the same institution, c) different college within the same institution, d) same discipline at a different institution, and e) different discipline at a different institution. Types of positions categorized into eight groups: a) teaching faculty, b) assistant professor, c) associate professor, d) professor, e) administrator, f) advisor, g) staff, and h) others.

Compositional measures were also examined with homophily, which is the preferential tendency for individuals to interact with those who are similar to them (McPherson et al., 2001). To measure the homophily across departmental affiliation and position, the E-I index (Krackhardt & Stern, 1988) was calculated using E-Net (S. Borgatti P., 2006). The E-I index is a method of calculating homophily across categorical variables. It examines the number of alters that have a different categorization from the ego (external ties E), subtracting by the number of alters that have the same categorization as the ego (internal ties I), and dividing the total number of ties for the ego. The E-I index is a reverse measure of homophily, so a more negative number equates to greater homophily (Perry et al., 2018a). The following equation presents the relationship between the external and internal ties and alters:

$$\frac{E - I}{E + I}$$

3.4.8 Validation Strategies

To ensure the trustworthiness of the findings, I utilized various validation strategies throughout the project (Creswell, 2013; Miles et al., 2019). As validation strategies are an important part of qualitative research, they were present from the point of data collection through the interpretation of the results.

Co-teaching and research network were triangulated by using both interview and archival data to understand participants' perceptions of their connections more holistically with other faculty (Tracy, 2010). Inter-rater reliability (Brennan & Hays, 1992) was also applied to both codes and subcodes with another engineering education graduate student serving as the second rater, the results of which are discussed in detail in Chapter 4. Additionally, the described above two methods served to improve the credibility of the data collection and analysis, respectively. After the data was analyzed, the resulting codes were shared with participating faculty members to ensure that their voices were expressed as they intended through member checking and potentially provide alternative interpretations of the results (Creswell, 2009; Tracy, 2010). After the initial analysis of the interviews and creations of the codes, peer debriefing was utilized to help account for the lead researcher's unconscious biases towards the research (Lincoln & Guba, 1985). No new themes were identified throughout the process.

3.4.9 Ethical Considerations

There are potential ethical issues pertaining to the data collection, the analysis, and the dissemination of the results. Prior to recruiting participants, the study was reviewed and approved by Virginia Tech's Institutional Review Board (IRB). All relevant training was completed by the researcher of the study.

At the start of the study, each faculty participant consented to the research which outlined the information to be collected (Perry et al., 2018b). The consent form described the purpose of the study, what the interview would cover, how the collected data would be protected and kept confidential, and who to reach out to if there were concerns. It was sent to the faculty as they were being recruited to the study via email. Then I made sure that the consent form was signed and if there were any questions about the study. The consent form used in this study can be seen in Appendix 2. After ensuring the consent form was read and signed, it was important to ensure that the participant knew that the interview was being recorded. Whether through a recording device or via Zoom, all participants were made aware that the interview was being recorded and if it was okay to record during the interview.

Part of the interview protocol was concerned with asking faculty to name other faculty that they had connections with and to discuss interpersonal barriers that might have inhibited their curriculum reform revision. Due to the sensitive nature of these questions to faculty, at the start of the interview, each participant was told that they did not have to answer any question they did not want to and did not have to give out any names of faculty they felt uncomfortable giving.

One of the most prominent ethical issues is the potential reidentification of faculty. During the semi-structured interviews, each participant provided names of other faculty they interact with. All names, both the participants and those that they mentioned, were given a unique identifier. After all tie and demographic information (position title, department, college) were collected for all individuals, names were replaced with the unique identifier and the identifying information was kept on a separate drive in the office of the lead researcher in a locked cabinet. It is standard in egocentric network research to not require the consent of the alters, as all information about them is publicly available (Perry et al., 2018b). To ensure the confidentiality of research data, all data

(i.e., interviews and social networks) was stored on a password protected computer and, on a USB-drive in a locked cabinet. Additionally, all participants were provided pseudonyms via a random name generator to ensure the anonymity in the dissemination of this research (Creswell, 2009).

Chapter 4 – Results

The experiences of faculty navigating the Pathways curriculum reform were organized into four topics, which were informed by prior literature, namely: 1) barriers and challenges, 2) faculty perceptions of organizational units' cultures of ethics, 3) institutional incentives and resources, and 4) faculty learning of ethics and pedagogical techniques. Each of the listed areas of inquiry were coded into descriptive themes, sometimes multiple times, via emergent *a priori* methods. The following results are organized by theme and the research question they are associated with. Sections 4.1 - 4.4 outline the results associated with Research Question 1, *What are the experiences of engineering faculty in developing courses with ethics components?* Section 4.5 outlines the results associated with Research Question 2, *What are the personal networks of engineering faculty who develop courses with ethics components?* Section 4.6 provides a summary of the findings presented in the prior sections of this chapter for both research questions.

4.1 Barriers/Challenges

When the initial thematic coding of the barriers/challenges was completed, I found nine themes within this larger category. To make sense of the nine themes, I categorized them into two groups, resource-driven and resource-driven barriers. The definitions for these two themes can be found in Table 5 below. The delineation of these two larger themes was driven by analyzing the Academic Plan and the Pathways for curriculum reform it describes. While the 9 sub-themes were created first, each of the ~60 excerpts for the barriers/challenges themes was organized randomly, the theme hidden, and resource-driven, influence-driven or both was assigned to each barrier/challenge.

Table 5. Definitions for types of barriers pertaining to curriculum reform

Barrier Type	**Definition**
Resource-Driven Barrier	Barriers arising from a lack of funding or time dedicated to a curriculum reform; a barrier/challenge that could be overcome with the addition of more resources
Influence-Driven Barrier	Barriers arising from an influence external to the faculty member in charge of a course; barriers that arise due to conflicts between two groups with influence over the course

Resource driven barriers are issues that can be largely remedied through investments of time or funding into the curriculum reform process. One way of thinking about these barriers, in terms of the Academic Plan framework, is thinking in terms of the educational environment. When iteration A and B of the educational environment differ, resources have to be added to the system to accomplish the change. This may look like faculty redesigning course material, graders learning how to grade a new type of assignment, or instructors simply needing the time and resources to learn how to teach new material. Both paths A and B from the Academic Plan highlight places where resource-driven barriers may arise, in the iterative process of the academic plan.

What resources are available within an Academic Plan are largely dictated by the second type of barrier, influence-driven barriers. In the Academic Plan framework, Lattuca and Stark (2009) highlight the ability for various groups to influence the educational environment. This can be done by institutions and agencies requiring certain content, or students and a discipline valuing content differently. These influences only become barriers when the influences that are exerted are different from the current educational environment. As an example, if ABET says that every engineering department must incorporate ethics in their curriculum, but a department already has ethical content because of disciplinary values, then there is no barrier because the current system aligns with the influencing groups.

4.1.1 Resource-Driven Barriers

In the following section, I present the findings for the thematic coding analysis that delved into the barriers that Pathways faculty faced due to a lack of resources, specifically time and funding, through the process of the curriculum reform. Resource-driven barriers were explored by analyzing transcripts, specifically in instances where faculty described the overarching process of the Pathways curriculum reform process and their implementation of the 'ethical reasoning' component of the Pathways curriculum into their course. Thematic coding revealed five distinct resource-driven barriers that faculty experienced throughout the curriculum reform process:

1. A credit saturated curriculum with not room to add new courses
2. The alignment of course materials, goals, and assessments with other courses
3. The governance aspect of the Pathways curriculum reform
4. Faculty preparedness to teach ethics
5. Inexperience in assessing ethics

Definitions for the five themes can be found in Table 6 below. All five of the themes were found emergently through inductive thematic coding. Additionally, the frequency of each theme is listed in the table below. The number (n) corresponds to the number of participants that listed the specific theme as a barrier through the semi-structured interviews. Themes were structured via the different personal and organizational structures that limited the resources of instructional faculty. The themes ranged in scope from a lack of preparation on the part of faculty to teach engineering ethics, to the alignment of the newly created course with the rest of the program's curriculum.

Table 6. Definitions and themes addressing the resource-driven barriers

Theme	Definition	n	Source
Packed Curriculum	Barriers arising from the packed curriculum and the difficulty of adding or shifting credits	8	Emergent
Instructional Alignment	Barriers derived from the difficulty of having to align the course material, instructional goals, and Pathways assessments across a series of courses or between similar courses in different disciplines	5	Emergent
Curriculum Reform Process	Barriers that arise because of the changes between the CLE system and the Pathways general education systems; barriers that arise from the difficulties of faculty navigating the Pathways system itself (i.e. confusing)	4	Emergent
Faculty Preparedness	Barriers arising from a lack of faculty preparedness to teach ethics in the engineering curriculum	3	Emergent
Inexperience Assessing Ethics	Barriers arising from faculty and GTAs having a lack of experience assessing ethics assignments	2	Emergent

With an overview of the diverse set of barriers that faculty experienced due to a lack of resources, it is now important to delve deeper into each theme. Excerpts from interviews with participants offer valuable perspectives on the barriers that faculty faced and the impact of the barriers on the incorporation of ethics into courses. Through close examination of these themes, we can develop a thorough understanding of the experiences of faculty in a prescriptive university-wide curriculum reform.

4.1.1.1 Packed Curriculum

Among the various resource-driven barriers that participants described, the most frequent theme had to do with the inability to add instructional material for ethics due to the amount of material and assessments within courses. Eight of the faculty described barriers pertaining to the amount of content they had to cover in their course, and the issues with adding and removing course content through the curriculum reform. While both ABET and Pathways require ethics and advanced discourse in programs, the requirements varied enough that faculty had to assess the two

separately, which increased the burden on the instructor and the students. In the following anecdote, Dr. Hardy describes their frustrations with the number of assessments that both they and senior capstone students have to complete due to requirements from ABET and Pathways:

> But there's so many assignments, and there's so much work in this class already. A large number of them are there only for ABET. There's a point where I can't keep adding individual assignments. In some cases, because there's 400 students, I just can't get that many assignments graded… They're doing so much stuff. So I'm not sure what it's going to look like for fall.

This excerpt emphasizes the increased burden of assessing students that Pathways put on instructors, even when the goals of the curriculum reform aligned with other program requirements from ABET. Another participant, Dr. Lowery, outlined a similar problem implementing ethics into their 1-credit professionalism course. They similarly expressed worry in trying to adequately assess over 300 students, describing that it is "yet to be seen is how much this course will actually improve student's writing." Both excerpts highlight the burgeoning number of assessments required by both them and students, with participants expressing worry for students over the amount of required work.

Shifting focus from the issues caused by adding material to a course without allocating appropriate resources, participants also described the barriers that present themselves when thinking of the curriculum as "a zero-sum game." In other words, adding the ethics content required by Pathways meant that other instructional material would have to go. In this excerpt, Dr. Adams describes the process of deciding what material to cut from a course:

> And trying to decide what to cut is hard. Because if you cut something, then you have to figure out depending on what you're cutting; is it cutting a separate lesson

> because I cover this material elsewhere? Or am I cutting this lesson because we really don't need it? Or if I cut this lesson, can I adjust these other lessons to make them cover this material. So there are a lot of decision points, there's a lot of work to alter a course structure. That's why it almost never gets done, unless you do a full-on course redesign, which is also a ton of work.

This excerpt highlights the many "decision points" that an instructor must consider when revising a course within the context of the larger program. Across all these excerpts two barriers that a packed curriculum presents are highlighted. In one case adding material to an already packed course places stress on both students and instructors. In another, instructors must make difficult decisions deciding what material can stay in their course. Shifting focus, the following section expands on the issue of course alignment that Dr. Adams described but expands on it to examine the barriers presented when material in courses is dependent on each other.

4.1.1.2 Instructional Alignment

Five of the twelve faculty highlighted barriers that were presented due to attempts to align materials, instruction, and assessment with courses taught by other faculty. Of the twelve departments in the College of Engineering, nine of them use a sequence of courses to meet their Pathways requirements instead of a standalone course. While this required less ethics material in each course, for these departments, it required faculty to coordinate to have the ethics material expand on prior courses. In the following excerpt, Dr. Gonzalez outlines the thought process they went through with colleagues in aligning their courses' material:

> So a lot of it was coordinating. 'What ethical discussions do we have in [the introductory course]? What type of discussions do we then have in [the senior capstone]?' To make sure that they're not just getting the same content in two

> different places but were actually building on each other. So that we create something that's a little bit more cohesive and comprehensive. So [the other instructors in the series and], and I sat down and basically came up with what content we were going to put in each of the courses.

The takeaway from this excerpt underscores a barrier in attempting to implement across the curriculum models of instruction as the participants noted the difficulty required to ensure coordinate material across the curriculum. However, not all participants who discussed instructional alignment framed it as a barrier. but rather as a part of the curriculum reform process. In the following excerpt, Dr. Baker describes instructional alignment:

> And it might sound like it was super collaborative, but it was really more about getting on board with what the courses were on. And this was a meeting, we probably had two meetings, maybe total, maybe four hours' worth of actual collaboration, and then it came down to individuals to put the plan in place. But then it required some modification within the individual courses… So, you know, we had to enhance some of the assessments. And so that then fell on to the, to the course instructors.

While both excerpts in this section describe how engineering departments tackled instructional alignment for ethics across the curriculum models, Dr. Gonzalez described the events as a challenge within the curriculum reform process, while Dr. Baker had a smoother experience in a more positive collaborative process. While both departments revised three existing courses and implemented ethics across all of them, it's evident that what faculty perceived as a barrier throughout the process varied. Switching gears, the next section focuses on the barriers of faculty

navigating the transition to a new curriculum model, and the role of governance in curriculum reform.

4.1.1.3 Curriculum Reform Process

Four of the twelve faculty described barriers associated with difficulties navigating the transition from the old curriculum (CLEs) to the new (Pathways), as well as the time requirement of the governance process associated with the transition between curriculum models. In the following excerpt, Dr. Baker outlines how a college-level plan for curriculum reform shifted to a department-level, integrative model:

> There were a lot of conversations at the college level about different models. And so this idea of having an integrated approach where we take Pathways content, and put it into existing courses within the curriculum already, that was not, as I recall, kind of part of the plan at the beginning. But you know, over the years that evolved… So that was probably the biggest challenge was getting clarity on specifically what we were able to do.

This excerpt highlights the complex nature of curriculum reform, and how it can significantly change due to a lack of resources. The takeaway from this anecdote is one of clear messaging on the part of change agents, and clear communication paths from change agents to the individuals in charge of the target level of change.

Focusing more on how the curriculum reform process affected specific courses, Dr. Hardy describes their experience working with the Pathways governance system to revise their course to allow for students outside of the department to meet their Pathways requirements:

> Hopefully it'll take 18 to 22 months, because getting a new course through the registrar of governance and through Pathways is a pretty onerous, or time-consuming task.

This excerpt describes Dr. Hardy's pessimistic attitude towards the expediency of the university governance systems at Virginia Tech. It underscores the complexity and of institutionalizing curriculum reform and the importance of sustained investment to a reform to enable faculty to iterate on their courses more effectively. This section emphasizes how accountability from institutional governance can serve to obfuscate and slow down the curriculum reform process, and the importance of communicating expectations and changes to all those affected by the curriculum reform. The next section focuses on an individual level barrier that affected faculty unfamiliar with incorporating ethics into the curriculum.

4.1.1.4 Faculty Preparedness

Three of the twelve participants outlined a lack of preparedness to teach ethics, from being unaccustomed to the pedagogical techniques associated with ethics instruction to the time required to update case studies to be more current and relevant. In this anecdote, Dr. Jenkins, who had decided to incorporate class discussions of case studies into their course, describes their unfamiliarity with facilitating conversations about ethics:

> And I remember being nervous about, are the students going to be inappropriate?... I'm not used to having those kinds of conversations in my classrooms. And I remember talking to the TAs at first about grading it and making sure that [they] don't grade [students] on their opinion, even if [the TA] disagrees with them, and [the TA] just has to go by the rubric. And but then it turned out to not be too big of a deal ever. I haven't had any problems with it.

This excerpt highlights a common concern of faculty in implementing new pedagogical techniques and assessment methods, that potentially inhibits them from experimenting with evidence-based pedagogies, despite not being issues once implemented. Another participant, Dr. Irwin, while comfortable with case studies in ethics instruction, describes the challenges of keeping case studies relevant and current:

> So there are definitely challenges just to kind of stay current and up to date and making it relevant, I always want it to be relevant to them, because the second it becomes irrelevant. Now, it won't be relevant for the students four or five years from now. Same with all the other concepts we teach.

The takeaway from this excerpt underscores that even when ethics content is present in the classroom, both it and the technical content may need to be updated to keep up knowledge of the field. Across these two excerpts, faculty discussed preparedness for their revised course in two ways, in the time requirement of updating instructional materials, and both the time requirement and comfort of using new pedagogical techniques. Shifting gears, the next section expands on the Dr. Jenkins' experiences with assessing ethics, specifically discussing the role of teaching assistants in the engineering classroom.

4.1.1.5 Inexperience Assessing Ethics

Two of the participants experienced challenges in implementing assessing ethics assignments in the revised curriculum, specifically around temporal barriers of preparing teaching assistants (TA) how to assess written assignments. In the following passage, Dr. Lowery, who is the instructor of a professionalism course situated in an engineering department, described the process of calibrating grades for written assignments with graders:

> And so we what we did was we had weekly meetings… I would choose between three and five student assignments at random… me and the seven graders would all grade and evaluate them and fill out the rubrics on our own. And then we would meet together and talk about how we did it. I am changing that for next year, though, because it was hard to keep up with. Like, [the graders] didn't have a baseline to start with… But it didn't really click with me till much later in the semester.

The main takeaway from this passage was that teaching assistants had varying degrees of experience with grading written work, which consequently requires more effort on the part of the lead instructor to prepare TAs for consistent grading. To iterate on what had been an onerous process to keep up with, Dr. Lowery went on to describe a plan to hold a pre-semester workshop with the teaching assistants to prepare them before the start of the next semester.

4.1.2 Influence-Driven Barriers

In the following section, I present the findings for the thematic coding analysis that delved into the barriers that faculty perceived as a result of influence from other organizations, during the Pathways curriculum reform. Influence-driven barriers were explored by analyzing transcript, specifically for instances where faculty described their experiences with the Pathways curriculum reform and the other individuals and organizations who played a role throughout it. Thematic coding revealed four distinct influence-driven barriers that faculty experiences throughout the curriculum reform process:

1. A lack of support from their home department
2. A push from the state and college to reduce credits
3. Varying student attitudes towards ethics in the engineering curriculum
4. The differences in values between academia and industry

Definitions for the four themes can be found in Table 7 below. All four themes were found deductively through the examination of Lattuca and Stark's (2009) Academic Plan framework. The number (n) corresponds to the number of participants that listed the specific theme through in their semi-structured interviews. Themes were structured across the different types of individuals and organizations that faculty perceived as playing a role in the Pathways curriculum reform. The influencing groups ranged from attitudes of students in the participants' courses to the different values engineering professionals place on ethics.

Table 7. Definitions and themes addressing the influence-driven barriers

Theme	**Definition**	**n**	**Source**
Lack of Departmental Support	Barriers arising from a lack of support from other members of the participants' department in the revision of their course	4	Lattuca and Stark (2009)
State/College push for reduced credits	Barriers arising from the state and college initiative to reduce credits in the curriculum	4	Lattuca and Stark (2009)
Student Attitudes toward Ethics	Barriers arising from lack of student receptiveness towards ethics in the engineering curriculum	3	Lattuca and Stark (2009)
Industry Influence	Barriers arising from differences in perceived importance of ethics between academia and a given engineering discipline	2	Lattuca and Stark (2009)

With an overview of the various institutional and external groups that hold influence over the engineering curriculum, it is now important to dive deeper into each theme. Excerpts from interviews with participants now offer perspectives on the various influencing groups that played a role in the Pathways curriculum reform. Through a close examination of these themes, we can develop a more thorough understanding of the situatedness of the curriculum in a larger sociocultural environment.

4.2.1.1 Lack of Departmental Support

The most frequently discussed theme was the lack of departmental support, with four of the 12 faculty members emphasizing a lack of support from former instructors of the Pathways course and a lack of departmental buy-in towards the Pathways curriculum reform from clusters of faculty. In taking over the Pathways course from another instructor, Dr. Hardy found that "The person who formerly taught [the course] hasn't been helpful at all. I haven't found really any help in my own department." Dr. Hardy went on to emphasize a lack of communication from administrators within the department about the changes that the Pathways course was required to make. The lack of communication led to Dr. Hardy seeking help from other organizational units on campus. In another instance of lacking departmental support, Dr. Adams describes their perceptions of why faculty in their home department were not supportive of a Pathways technical writing course:

> I believe not everyone has taken a technical writing course and/or has a strong belief in the need for it as myself and some other faculty. So it's not the kind of course where everyone is like, 'Oh, for sure why, aren't we doing this.' And again, part of that is driven by that faculty know, if that goes in, something comes out. And you know, no one wants to lose their courses. They love teaching their courses in their areas. So that makes it really hard again, that's why we're so glad when there's a requirement for it, because now we had to do it.

In this excerpt, Dr. Adams describes their perception of why other faculty pushed back on the creation of a writing course, namely that other faculty had not taken one themselves or believed that technical writing was important for engineering students. This excerpt underscores how faculty perceptions of courses not centered around technical, disciplinary knowledge might be seen

as extraneous to the curriculum. Expanding the discussion to beyond the department, the next section concerns a college-level push to reduce credit that occurred around the time of the Pathways curriculum reform.

4.2.1.2 State/College Push to Reduce Credits

Four of the twelve participants discussed a specific, state initiated, college-level push to reduce credits across all programs within the College of Engineering. As described more thoroughly in Chapter 3, just before the start of Pathways in 2017, a push was made from the state, namely the State Council of Higher Education for Virginia (SCHEV), leveraging influence over college administration to reduce credits across the program. In the following passage Dr. Adams, a department level administrator, describes their perceptions for the push:

> When our peer institutions throughout the United States, rank higher than us, and you can get their degree in 118 credits, they're not going to come here, when it's 135 credits, it's just an extra semester almost.

This excerpt underscores a faculty perception that institutions are comparing themselves to and competing with one another. To add to this, Dr. Adams also described the impact of the push to reduce credits in tandem with the Pathways curriculum reform on the duration of the curriculum changes made in their department:

> This is all in parallel. It took three years to get the curriculum done; there's only so many changes you can make per year.

Further complicating the curriculum changes needing to be made by each department, the two tandem initiatives took some departments nearly three years to complete. In addition to providing added complexity to the curriculum reform, Dr. Faulkner described how the push to reduce credits dictated the model for Pathways integration into their program:

> It was very important to us to get the Pathways requirements intertwined with what we were already doing, right? Because if we couldn't do that, then we had to add credits. And nobody was in a position to support adding credits.

Instead of adding credits to the curriculum, Dr. Faulkner describes how the push from the college effectively dictated the department utilize an integrative approach to accommodate the Pathways requirements. This section underscores the difficulties of accommodating the influence of multiple organizations, specifically when they contradict and that both internal and external influencing groups can directly shape the structure of the engineering curriculum. Focusing the discussion of influence within the classroom, the next section discusses how student attitudes towards ethics posed as barriers to curriculum reform.

4.2.1.3 Student Attitudes toward Ethics

Three of the twelve participants described the negative student attitudes towards faculty implementation of the Pathways initiative, specifically of negative reception towards ethics content. In the following excerpt, Dr. Collier outlines why they felt disappointed in the efforts of their students towards student responses of an ethical case study:

> What I found, at least early on in the semester, the first time that I was teaching it, is that the students didn't seem to care. You would look at the number of submissions out of this 500-person class, three hours before the deadline, and there would be 40 submissions. And so the vast majority of them were students hurrying through, writing a quick essay, that they weren't really thinking all that much about an hour before the deadline.

Dr. Collier would go on to describe that in the next semester, they would go on to reduce the number of overall essays from four to two but increased the rigor of them. They would go on to

say that "I think the students did seem to pay a little bit more attention to those and to care a little bit more about those" referring to the essays in their second iteration of the course. These excerpts underscore how faculty perceive student receptions of ethics material and respond when faculty feel there is a negative perception. Dissimilarly, in their integration of a class discussion on various ethical dilemmas, Dr. Jenkins expressed concern for student receptions towards the new pedagogy stating that "And I remember being nervous about like, you know, are the students going to be inappropriate?" Dr. Jenkins went on to describe that there hadn't been any issues with the integration of the new pedagogy in the course, and that they were going to expand on it the next iteration of the course. These quotes highlight how faculty may perceive students to not be prepared for ethics content, which in reality they may be. Shifting gears, the next section focuses on the role the engineering industry plays on students' perceptions of disciplinary ethics.

4.2.1.4 Industry Influence

Two of the twelve participants stressed the influence of how discrepancies between academic and industry valuation of ethics impacted student perceptions of ethics. Both participants that discussed this theme were from the same discipline. In the following excerpt, Dr. Baker describes their perspective on the role that industry plays in subverting the promotion of ethics in academia:

> But the reality is that once they step [into industry], it doesn't necessarily line up at all with what we teach. And this is why [our discipline] has this problem. Because, you know, we're teaching the book definitions of ethics; we're trying to do it in a way that's very applied. But then they get out there, and they see people

are not acting ethically. And so long term, I don't know what the impact is, of the ethical reasoning components on their ethical performance.

In this excerpt Dr. Collier describes the differences between industry and their department's perspective on ethics, adding that they are unsure of the magnitude of influence caused by the lack of emphasis on ethics within their discipline. It underscores that once students leave academia for industry, it is difficult to measure the impact that aspects of their education had on them.

4.2 Faculty Perceptions of Organizational Cultures of Ethics

To answer the following research question, *What are the experiences of engineering faculty in developing courses with ethics component?*, I asked faculty to describe their perceptions on the culture of ethics within various organizational units within Virginia Tech through semi-structured interviews. In the following section, I present the findings for the thematic analysis that delved into faculty perceptions of various organizational units at Virginia Tech. Specifically Participants were asked to describe the culture of ethics within their home department (which varied), the College of Engineering, and Virginia Tech as an institution. Faculty perceptions were explored through analyzing transcripts, specifically in the section that asked participants to describe their perceptions of the culture of ethics across the three levels of institutional organization. A summary of the emergent themes across the three organizations is presented below in Table 8. Themes were organized by the level of care and rationale for the care that faculty perceived.

Table 8. Summary of faculty perceptions of ethics across levels of institutional units

Organization	**Summary**	**n**
Department	- Importance of ethics in discipline extending to the curriculum	8
	- Pockets of faculty that care more than others	3

	- Department does not place an emphasis on ethics	1
College	- "It's automatically build into ABET"	5
	- The college is pretty solid/ there is a genuine emphasis	3
	- Faculty did not feel informed to speak to the culture of the college	2
	- Emphasis on supporting DEI	2
University	- Content that ethics is being discussed at the University level	4
	- Pathways is great, but limited in its scope	3
	- Faculty did not feel informed to speak to the culture of the college	2
	- Do not believe the university support is genuine because of:	
	- University response to COVID	1
	- University spending	1
	- Honor System	1

4.2.1 Faculty Perceptions of Home Departments

Faculty perceptions of their home department varied. Some saw their home as a sort of exemplar within the college, while others felt that only pockets of faculty 'really' cared about ethics. The results were not discipline-specific, as there were faculty from the same department that disagreed on their department's culture. Eight of the participants described an emphasis on ethics within their department, due to the nature of the discipline, for better or worse. In the case of Dr. Duncan, they stress the importance of ethics as "the nature of discipline," further discussing the human impact of the discipline. In contrast to this Dr. Irwin felt it was more ethics was intertwined with the nature of the discipline, specifically as a response to the lack of a culture of ethics within the industry.

> [Ethics] is very important in our department... And the reason for it, is the industry.
>
> [Our discipline's] industry is notoriously the most unethical industry that exists,

> period. And that's why we can't put [ethics] in enough. We can't teach them enough. We can't prepare them enough. And we, I, find it very important.

The contrast between these two excerpts highlights that while two faculty in different departments felt their department cared about ethics, Dr Irwin's perception was due to lack of emphasis placed on ethics within industry, while Dr. Duncan's was in seeing their discipline and industry as an exemplar.

Two participants described pockets of faculty within the department that they felt cared more about ethics than other faculty. Each participant described the impetus for this striation of faculty in different ways. Dr. Collier prescribed the differing levels of interest in ethics as derivative of the research interests of the faculty within their department:

> There are definitely faculty who are interested in exploring ethical challenges and ethical problems, especially associated with the research that they're doing. Whereas others aren't. And that's just a factor of what kind of research are they doing.

This excerpt highlights Dr. Collier's perception that an individual's emphasis on ethics may be in some ways dependent on their interest in other applied contexts, namely research. Dissimilarly, in the following excerpt, Dr. Hardy described a split culture of ethics within their department because of faculty acting unethically and setting a poor example for students in the meantime:

> I could come up with half a dozen examples of where tenured faculty people in my department have done something unethical. It's not that they're not teaching ethics correctly, it's that their own behavior is not above board… I think people lead by example… I'd say there's a small population in my department that lives ethically

> and behaves ethically and teaches ethics and expects the students to be ethical. And then there's a whole different group of people that don't do any of it.

This excerpt highlights the idea that students not only learn from the instructional material, but also that a department's culture towards ethics may spread from faculty to students, and the importance of conducting oneself accordingly. One faculty member described that their department did not have a positive culture of ethics, except for when they were required. In the following excerpt, Dr. English describes their perception of their department's culture of ethics:

> It's not I think, in [my department], at least in the past, it's not really focused on right. I mean, when you get to the ABET accreditation, you realize that you need some of this in there. But the development of that material up front has not been a focus, I think."

This excerpt emphasizes the idea that some faculty, and to an extent departments, only care about ethics when they are mandated to by accreditation. Across all of the differing faculty perceptions emphasized throughout this section, results suggest that department in the same college not only has their own separate culture of ethics, but that there are populations within departments that value ethics differently. The following section takes a step back from the department to explore the emergent themes of how faculty perceive the culture of ethics within the College of Engineering.

4.2.2 Faculty Perceptions of the College

In the same way that some faculty perceived there to be a lack of a cohesive culture of ethics within their department, faculty felt that the emphasis placed on ethics across departments varied wildly. Two of the twelve faculty described not feeling informed enough to comment on the culture of the College. Three faculty cited feeling that they felt the efforts of the College of

Engineering were “pretty solid” (Dr. Hardy) and “that there is an emphasis, and that the emphasis is genuine” (Dr. Kirby). While these two faculty members felt that there was a genuine effort on the part of the college, others felt that the efforts were less uniform across the college. In the following excerpt, Dr. English describes the emphasis on ethics across the College as haphazard:

> It feels haphazard, kind of, like some departments are doing more, and some departments are doing less. Everybody's trying to do the bare minimum because they have to make the accreditation.

This excerpt emphasizes that regardless of the level of effort being put on ethics in the engineering curriculum, there is at least a baseline level being met due to accreditation across the college. Dr. Irwin on the other hand, felt that there was a lack of ethics being pushed at the college, and that departments were the ones pushing to meet the minimum standards set by accreditation:

> So the college, I don't really know. I'm not aware of any college level initiatives related to putting it into the curriculum. However, we're engineers, we're an engineering school. We're an engineering college. It's automatically built into ABET. And engineering requirements. So it is there, it is already required. It's doesn't seem like it needs to be like pushed from a college level, because it's pushed up the other way.

This excerpt highlights the importance of communication channels between college administrators and departments, and that some faculty may see ethics as a disciplinary activity, to be pushed by each department rather than the college.

The other specific example detailing a culture of ethics within the college was surrounding efforts of Diversity, Equity, and Inclusion (DEI). Expanding on their belief of genuine effort on

the part of the college, in the following excerpt, Dr. Kirby described their perception on the college-wide efforts to improve DEI:

> I think the enrollment numbers are better in some departments, but they're still not great. Engineering is still predominantly male, and it's predominantly white, and we got to fix that. So, at the college and department levels, I think there is an emphasis and I think that emphasis is genuine.

This excerpt highlights the interrelatedness of DEI and ethics education and a recognition of recent efforts made on the part of the college to improve DEI. The excerpts across this section underscore the lack of cohesive efforts to build a culture of ethics within the College of Engineering, with the plurality of faculty emphasizing that ethics with the college present to accommodate accreditation. The following section takes a step back from the college to examine faculty perceptions on the university's culture of ethics.

4.2.3 Faculty Perceptions of the University

When faculty were asked about the culture of ethics at Virginia Tech, there were generally four responses. The most prominent perception was eloquently expressed by Dr. Faulkner, in that they were "pleased to see an ethical component being talked about at a university level." Three of the other participants responded similarly, with a general contentment that ethics was being discussed at the university level. The next most discussed theme was among faculty who were excited about the prospect of Pathways, but also understood its limited scope. In the following excerpt, Dr. Collier describes the limitations of the Pathways curriculum:

> I think the university is doing great work. But what maybe 15% of all of the courses over the four university or pathways courses, and I'm just pulling that number out of thin air, I don't know if it's a little bit of a highest amount, a little bit of a low

> estimate. But it's a, it's a small subset of classes compared to everything that the university teaches. And so if there was maybe more of a university initiative that really pushes that, hey, we've learned these lessons from pathways, we want this to be a part of every course now, that would probably be the best thing that the university could do.

This excerpt highlights that while the required 'ethical reasoning' component was only required by a subset of all courses across the university, Dr. Collier felt that it set a positive framework that could be built upon in future iterations of the general education curriculum. Of the faculty that emphasized the culture of ethics in a positive light, they primarily did so by describing the efforts of the Pathways curriculum.

For faculty who felt that the University had areas for improvement regarding a culture of ethics, multiple areas across the university were cited. In the following excerpt, Dr. Kirby describes why they find it difficult to take Virginia Tech's efforts seriously:

> I do not believe that the emphasis is genuine at the institutional level. Okay. I believe that they at the institutional level it's convenient. If it's convenient to talk about ethics and to enforce ethics then they will, but if it's inconvenient, they won't. It is hard for me to take seriously an institution with a with $100 million athletic department because the ethics behind it are such that we're okay.

This excerpt highlights how university spending can affect how faculty perceive the university and may in the process alter their perception of it. In a continuation of the conversation outlining their perception of the university's culture of ethics, Dr. Kirby also described their disappointment with the university's honor system:

> But if the ethical thing to do costs $10 million, and the odds of you being caught not doing it or zero nothing is going to get done. So the institution needs to do that. And how does the institution do that? A pretty ruthless honor system. Do we have that? No, our honor system, the way our honor system is constructed is not. It's not set up to do that.

Expanding on the previous passage, this excerpt highlights how a lack of congruity across university budgets and systems can mitigate faculty support of other initiatives. Finally, a third participant, Dr. Baker described what they felt was a mishandling of the university's response to the reopening of the University after the COVID pandemic:

> We didn't give people for instance, an opportunity to say, 'I don't feel comfortable with a vaccine. And so I'm going to take a semester off until this all gets worked out.' We got them enrolled; we locked them in. And then we said, 'Oh, by the way, here are all these extra requirements.'

This excerpt highlights the participant's perception that the university is running like a business, thinking of the bottom line before the students. Across all three of the excepts describing participant's lack of faith in the university's attempt to emphasize a culture of ethics, participation felt that there was a lack of cohesion across budgets, university messaging, and curriculum initiatives. Across all these themes present within the faculty perceptions of the university's culture of ethics, results suggest that budgets, messaging, and initiatives all affect how faculty perceive their institution and that a lack of congruity can lead to faculty feeling that initiatives are not genuine.

4.3 Institutional Incentives/Resources

To answer the following research question, *What are the experiences of engineering faculty in developing courses with ethics component?*, I asked faculty to describe the institutional resources and incentives they utilized across 12 semi-structured interviews. In the following section, I present the findings for the thematic analysis that delved into the incentives and resources provided by various organizations within Virginia Tech that faculty perceived as helpful throughout the Pathways curriculum reform. Institutional incentives and resources were explored by analyzing transcripts, specifically in instances where faculty described their experiences with the Pathways curriculum reform and drivers that helped them through the process. Thematic coding revealed five distinct institutional incentives and resources provided by organizations within the university that faculty perceived as having utility in the Pathways curriculum reform:

1. Collaborations with faculty external to the participant's home department
2. Instructional programs sponsored by Virginia Tech
3. Curriculum review within the participant's home department
4. Institutional governance processes affiliated with Pathways
5. Funding provided as a part of the Pathways curriculum reform

Definitions for the five themes can be found below in Table 9. All the themes were found emergently as institutional incentives and resources are dependent on the change initiative. Additionally, the frequency of each theme is listed in the table below. The number (n) corresponds to the number of participants that listed the specific theme as a resource or incentive during interviews. Themes were structures by the mechanism and the organization providing the resource or incentive. The resources ranged in origin from departmental to institutional, and the mechanisms ranged from financial incentives to design courses to conversations between faculty to provide guidance on specific course revisions.

Table 9. Themes and Definitions of Institutional Resources and Definitions

Themes	Definitions	n	Source
Interdepartmental Assistance	Participant worked with another department or administrative group to help them through the Pathways process	5	Emergent
Pathways Instructional Programs	Participant took part in a seminar or workshop to learn about the Pathways program and receive feedback on their course.	4	Emergent
Internal Department Level Review	Participant took part in or received feedback from a committee within their department which looked at the revised curriculum of their course	3	Emergent
New Pathways Governance	Participant received feedback from the formal Pathways governance process	3	Emergent
Pathways Funding	Participant received a Pathways grant or other funding to assist them in revising their course	2	Emergent

4.3.1 Interdepartmental Assistance

Five of the faculty members described different ways that they received feedback or help from other departments or administrative groups through the process of the curriculum reform. In one example, Dr. Collier described that another department that was wanted to include a newly created Pathways course as a formal part of their program. The interest from the other department lead to a meeting between the two departments to "give a little bit of feedback about what the pipeline goals might be" of the course. This excerpt highlights that when other departments have a vested interest in the success of a curriculum reform, they may be willing to provide resources to ensure the success of it.

While some engineering departments worked directly with faculty in other departments, others worked indirectly, receiving governance and course materials to serve as a proof of concept. In the following passage, Dr. Baker describes how they leveraged another department's idea to integrate Pathways requirement across a series of courses:

> [A professor] over at [another engineering department] got [their] Pathways course approved before ours. And that was really for us the proof of concept if you will, that we can do this right because there had not been anyone who had done this kind of integrative approach and had the courses approved. And so [that department] kind of took the lead on that and then what it said to us was 'okay look, we can carve out these one credit chunks to meet these requirements.'

In this excerpt, Dr. Baker describes how another department served as a proof of concept for the integrative model of meeting Pathways requirements across a series of courses. This excerpt highlights how actors within a change initiative can leverage each other's ideas and resources to meet requirements within a prescriptive change initiative. Across the excerpts, this theme underscores that in large institutions, even when change is happening at a department-level, interdepartmental interactions can serve as drivers for curriculum change. The next section shifts gears to an institutional resource provided by the university change agents as a part of the Pathways curriculum reform through instructional programs for faculty developing Pathways courses.

4.3.2 Pathways Instructional Programs

Four of the twelve participants described their experiences attending university-sponsored professional development programs such as the Pathways Summer Institute (PSI), which were mandatory for faculty who had received Pathways grants. Faculty who received Pathways grants were also required to attend cohort meetings 2-3 times over the course of the academic year, which provided a platform for faculty to discuss how they integrated ethics into their curriculum and receive feedback from other faculty. In the following excerpt, Dr. English, who had received a Pathways grant to assist in the redesign of their course described their experiences with the program:

> In the past three years, I probably have done six or eight of those. And part of that's because I heard a few of them were required, but I was just interested as well to improve my teaching. And so they had, they had faculty, conversational groups that were optional. Where they would group a number of faculty, I think six of us together, and all of those faculty were teaching a Pathways course. And so you could ask questions about problems you had, or, you know, considerations.

In this excerpt, Dr. English describes attending more than the required number of Pathways meetings, as the participant was motivated to improve their teaching and they felt that the meeting held utility. Additionally, the meeting served as a platform for instructional feedback to pedagogical experimentation and interdisciplinary discussions of ethics.

Other participants described Pathways instructional programs not only as platforms to disseminate pedagogical techniques, but also as mechanisms to overcome specific instructional challenges of this study's participants. In the following passage, Dr. Irwin described a specific challenge they were facing in assessing their ethics assignment, and how the Institute provided a platform for overcoming the barrier:

> Because it was when I was thinking about how to create assignments around ethics. What is acceptable in terms of like, what they're doing? How do you grade and ethics assignment was a big question for me because… right and wrong sometimes has a little bit of nuance, how am I deducting a point or two for this group or that group? And how do I define what those points are even really worth? So them sort of explaining that sometimes it's more about the process of them completing and not really did they check a box. That sort of helped me in developing the content of

> ‘How do I relate ethics to construction? How do I make it tangible or applicable? How do I turn it into an assignment that I can put forth?

This passage emphasizes Dr. Irwin’s lack of experience in assessing more nuanced ethics material and how faculty from other disciplines can provide a different perspective on ethics assessment. The results of this section suggest that institutional instructional programs provide a platform for faculty to share pedagogical techniques, knowledge of ethics, and receive feedback. The next section shifts the focus from resources provided at a university-level to one at the unit of change within the Pathways curriculum reform, departmental curriculum reviews.

4.3.3 Internal Department-Level Review

Three of the twelve participants discussed receiving feedback from faculty groups and committees within their home department that centered around Pathways course material. Two participants highlighted the use of the pre-existing undergraduate curriculum committee adding an additional cycle of review specifically for the ethical component of the new course. In the following excerpt, Dr. Baker provides an overview on the role of the departmental curriculum committee in the overarching Pathways process:

> I mean, we did add some rigor, and some structure around some of the ethics content. And that's always a concern, because, you know, if we're adding this, what's coming out? But again, that is kind of the normal process of curriculum review. And so in a way, it just forced us into an additional cycle, focused specifically on ethics.

This excerpt highlights how the department review helped to address the issue of an overloaded curriculum due to meeting additional Pathways requirements, as well as how review of a curriculum reform can potentially be integrated into current department review practices. While

the first two participants described the utilization of a curriculum committee in curriculum reform, the third participant described a different committee within their department. In this passage, Dr. Hardy describes how their department leveraged an ABET accreditation preparedness committee to review Pathways changes:

> Ahead of our most recent ABET re-accreditation, we had an undergraduate committee on ABET preparedness review all the classes we were going to be using assessed data from and make sure that we thought the assignments and the rubrics were rigorous enough to meet the ABET standards. And during that process, we revamped homework assignments and rubrics in multiple classes for all the different ABET requirements.

In the above passage, Dr. Hardy highlights the role of an ABET preparedness committee in assisting them with the revision of instructional material. The excerpt underscores the ability for departments to leverage existing faculty knowledge of ethics and resources in curriculum reform. Additionally, it highlights how existing resources to develop ethics content in the engineering curriculum can be leveraged to ease the burden of a curriculum reform. Each of these two excerpts underscored the ability of departments to leverage existing mechanisms of curricular review in revising both the integration of ethics into a curriculum as well as the pedagogical techniques utilized within it. The next section extends beyond disciplinary boundaries, focusing on faculty perceptions of institutional feedback on Pathways courses at the college and university level.

4.3.4 New Pathways Governance

Three faculty described the role of college and university-level governance in providing feedback to Pathways curriculum designers over their course. As a part of the new Pathways requirements, any course that was designated as a Pathways course was required to go through an

additional round of governance, to ensure that the course met the specified Pathways objectives. In the following passage, Dr. Adams describes the feedback their technical writing course received from both the college and through Pathways:

> I recall that there was a good amount of feedback. I remember there was the usual college level of feedback. But understand that was because this is the kind of course that the college doesn't usually see. Right, because they're reviewing technical content courses. So [my course] was kind of different. And I recall, there's feedback from the pathways committee and the people involved there. So I'm just pulling up the comments from the pathways committee when the course went in. Um, not a lot of comments. Again, it went quite smoothly, it was things like a support letter, which is normal. Examples, make sure you have examples.

In this excerpt, Dr. Adams describes the amount of detail provided by the college level review, citing that it might have been due to a lack of unfamiliarity with technical writing courses. The excerpt highlights the varying levels of detail that institutional levels of review can provide for a course.

Another aspect of the Pathways curriculum review process was to recruit faculty with backgrounds in pedagogy from within the university to serve as peer reviewers for Pathways courses. Dr. Duncan, who has a background in pedagogical training, was recruited by another faculty member to serve as a reviewer for Pathways. In the following excerpt, Dr. Duncan describes the process of providing feedback to Pathways faculty from the reviewer's perspective:

> So you got partnered up with someone. It changed every time. I think we met every two weeks. And so the week before, you email with the other person who reviewed the same [course] and say, 'This is what I think; this is what I found. What about

> you?' And then we send it to the person who proposed it. And then the in-person meeting is when they have a chance to kind of verbally clarify or bring those edits so they can get it approved.

This excerpt describes Dr. Duncan's experiences with governance from a reviewer's perspective, highlighting a multi-step process of curriculum reform that provided instructional faculty with formative assessments of their course from multiple faculty with pedagogical training. The results suggest that faculty revising courses within the College of Engineering had multiple opportunities for curriculum review from outside their discipline, which may serve to mitigate disciplinary ethical blind spots. The next section maintains the focus on resources provided by the university but shifts to discuss funding opportunities for faculty within the Pathways curriculum reform.

4.3.5 Pathways Funding

Two of the faculty described receiving funding from the Pathways program to create a new engineering course that met the 'ethical reasoning' integrative learning objective. To provide some context, faculty could apply to receive a grant from the Pathways administrative group to support summer funding, TA/GA support, and instructional materials. Most Pathways grants were awarded to faculty who sought "funding to develop a course" or minor, as was the case for Dr. English. However, Dr. Collier was asked by Pathways administration to create a course due to a lack of intermediate courses to meet one of the Pathways requirements:

> The initial request for us to have a an intermediate [programming] class came from the [Pathways administration], thinking through the idea of 'we need to have more of these higher level quantitative pathways courses. Computer Science already has one, though it's mostly something that [in-major students] take. Math has one, but it's a higher-level math class... the students are struggling to complete this this

> pathways requirement. Would it be cool if you had a follow-on class to [an introductory programming course] that you wanted to develop, and hey, also, we'll give you 10k in funding to help develop it.'

This excerpt highlights that change agents within the Pathways administration were evaluating the transition between curricula and identifying gaps in the types of courses being offered. The findings also underscore the importance of tracking curriculum reform to address gaps in dissemination or provide incentives when diffusion stagnates.

4.4 Faculty Learning of Ethics/Pedagogies

To answer the following research question, *What are the experiences of engineering faculty in developing courses with ethics component?,* I asked faculty to describe the various methods by which they developed their understanding of engineering ethics and its associated pedagogies. In the following section, I present the findings from the thematic coding analysis that delved into how faculty, when supported by incentives and resources from their university, college, and department, faculty developed their understanding of ethics and pedagogical techniques. Faculty's professional development was explored by analyzing transcripts, specifically in instances where faculty discussed how they incorporated the 'ethical reasoning' component of Pathways into their course. Thematic coding revealed five distinct methods by which faculty acquired knowledge about ethics and pedagogical techniques for its integration:

1. Independent learning
2. Participation in seminars and workshops organized by entities within Virginia Tech
3. Drawing from prior experiences
4. Engaging in conversations with peers
5. Formal education on ethics

Definitions of the five themes are presented in Table 10 below. Each theme is listed as emergent or *a priori* with the associated literature for the latter. Additionally, the frequency of each theme is listed in Table 10, with participants being able to provide more than theme throughout their interviews. Themes were structured based on the level of organization and support that participants utilized, ranging from organizational opportunities through formal seminars and workshops to more self-directed learning, which included consulting textbooks, other courses' materials, or online resources. Notably the examination of these five themes extend beyond merely learning about ethics; it encompasses the acquisition of pedagogical skills required to integrate ethics into the classroom.

Table 10. Themes addressing faculty learning of ethics and pedagogical techniques

Themes	**Definitions**	**n**	**Source**
Individual learning	Participants utilized textbooks, other course material, or did their own research to learn about ethics and how to teach it	6	Emergent
Prior work/ Experiences	Participants had first-hand experience with ethics or teaching ethics in their prior work, either in engineering or other fields	6	Polmear et al. (2022)
Seminars/workshops	Participants attended seminars or workshops organized by an institution outside of their department to learn how to incorporate ethics into their curriculum	5	Lattuca and Stark (2009)
Conversations with friends/colleagues	Participants talked with friends and colleagues about ethics and/or how to revise their curriculum	3	Emergent
Formal education - undergrad or grad	Participant took ethics related courses during their undergraduate or graduate education	3	Emergent

With an understanding of the diverse methods through which faculty members acquired knowledge about ethics and pedagogical techniques, it is now imperative to delve deeper into each theme. Extracts from participants' interviews provide valuable insights into their experiences, shedding light on the nuances of their approaches and the impact of these strategies on the integration of ethics into their teaching practices. By examining these themes closely, we can glean a comprehensive understanding of the dynamic processes involved in incorporating ethical reasoning into curriculum design and delivery.

4.4.1 Individual Learning

Six out of the twelve faculty members interviewed underscored the role of informal, independent learning in fulfilling the objectives of the Pathways curriculum reform, particularly emphasizing the integrated objective of 'ethical reasoning'. These faculty members augmented their knowledge of disciplinary engineering ethics, ethics law, and ethical theories by utilizing disciplinary textbooks, professional exam study guides, disciplinary Responsible Conduct of

Research (RCR) trainings, and online materials. Most participants described using relatively few source materials to learn about ethics. As one participant, Dr. English described it, "I just did some searches for like, summaries and ethical theories. While most faculty focused their ethics learning within one discipline and medium, a counterpoint to this finding is elucidated in the following anecdote from Dr. Irwin, as they describe the process of gathering ethics material for their course:

> And so there's ethics chapters in our law texts, not just the current textbook that I have, but the older ones that I've got on my shelf from when I was in school… I pulled a lot of those out of my like engineering study materials like from your FE exam and your PE exam, you get the big study books that has like the chapter in the section on ethics. So those are the bodies of knowledge that I'm pulling on, I'm not really referencing any major ethical texts. I mean, even some of my research is online research. It's a little bit loose, but there's a lot of ethics out there. So it's not like, I don't know, there's not like the ethics holy grail book, if there was I would have heard it by now.

The takeaway from this excerpt examines the multifaceted nature of engineering ethics, as well as the use of multiple mediums foster multi-disciplinary understandings of ethical principles. The contrast between these two excerpts underscores the hazards of individual learning. When faculty limit the scope of their individual research to one specific discipline, they limit their understanding of ethics to their domain specific discipline. By extending individual knowledge gathering beyond disciplinary boundaries and across mediums, faculty might gain a more nuanced understanding of ethical principles and how they apply across disciplines.

Some participants needed specific ethics knowledge from their own domain, whereas others were pulling specifically from other disciplines applications of ethics. Finally, some

participants, like Dr. Gonzalez cited that most of their time was spent learning "the best ways to teach ethics to undergraduate engineers in general," specifically how to introduce students in their discipline to ethics instructions. The major takeaway from this section is to emphasize the different levels of faculty preparedness that participants went into this curriculum reform with. Shifting focus, the following section examines the role of participants prior work and experiences in industry, specifically in the creation of pedagogical techniques via case studies.

4.4.2 Prior Work/ Experiences

Six of the twelve faculty members talked about their time in industry as a resource in creating pedagogical instruments. Five of the participants were Professors of Practice, which at Virginia Tech means they had spent a significant amount of time in industry as an engineer, with the expectation of leveraging their connections and experiences in teaching and service to the department. Faculty brought both positive and negative first-hand experiences with them to the classroom that they had faced during their time in industry. Four participants had first-hand experiences with whistle blowing, data falsification, and bribery that they used in their classes as real-life professional ethics case studies. In the following anecdote, Dr. Lowery, describes their negative experiences in industry:

> And so one of the discussion posts I had, I pulled actually from a real world experience, it was something I experienced when I worked at the government where a federal employee wanted the contractors to write something untrue in their reports. And [the federal employee] said 'I want you to skew this data so that it privileges this form of energy instead of this.' And the contractors were at a crossroads. And they didn't know what to do. They were like, 'should we write this

> report, as the federal employee wants us to write it? Or should we write it in a way that is more accurate to the data?'

This excerpt highlights the specificity of the case studies that were created as a result of negative faculty experiences in industry and the level of authenticity it provides to engineering students who are preparing to enter the workforce. All four of the faculty members' other negative experiences were concrete examples of unethical behavior that were discussed or presented in the classroom in some form.

While a majority of the faculty highlighted specific negative experiences associated with ethical dilemmas in industry, two participants highlighted how their experiences in industry positively impacted their view on professional ethics and bringing that to the classroom. Those with positive experiences reflected on the nature of their discipline importance to applied ethical areas, namely diversity, equity, and inclusion (DEI) and safety. In the following anecdote, Dr. Adams, who previously worked in the aerospace industry working on components with large potential for human impact, describes the importance of ethics in their role:

> So just the nature of the industry that I worked in… just the nature of the work I was involved in, and the importance of what happens if there's a failure, you know, that drives into the need for ethics. And so I really kind of learned just from the nature of the things that I was involved with. That's, that's the way they were they were like a massive scale of failure can be real trouble.

This excerpt underscores the emphasis industry places on ethics is disciplinary-specific, meaning that as departments that prepare students for a plethora of industries, they also need to prepare ethics material for student seeking a multitude of roles. For the faculty had negative experiences within their prior work, the experiences became authentic case studies and launchpads for

discussions with students in the classroom. Faculty who had generally more positive experiences brought less explicit material to the classroom from their work experiences. Switching focus, the next section focuses on the primary method through which faculty learned ethics at the institutional level. Specifically, faculty leveraged seminars and workshops offered by Virginia Tech and outside organizations to further their understanding of engineering ethics.

4.4.3 Seminars/Workshops

Five of the twelve interviewed faculty actively participated in workshop organized by organizations at Virginia Tech, such as the Center for Excellence in Teaching and Learning (CETL), the Pathways Summer Institute, and the American Society for Engineering Educations (ASEE). These workshops served as a platform for discussions, feedback, and inspirations of pedagogical techniques. For instance, the Pathways Summer Institute, which was an initiative designed to designed for faculty involved in Pathways to share pedagogies and receive feedback from other instructors from across the University. One participant, Dr. Collier, who had received funding to design a course for Pathways was part of a group of faculty that met once a month as part of the Institute described the activities of the Institute:

> [We] got together once a month and just kind of chatted about pathways, chatted about [our] experiences, presented something relevant to what they were doing for the class or the minor that they were developing.

As a part of the institute, Dr. Collier described a rotating presentation that one member would give at each meeting to serve as a starting point of discussion. One of the barriers to curriculum reform that Dr. Collier had outlined prior to this point was the negative student attitudes towards the ethics assignments. The participant felt that students were "just scraping these short essays together an hour before the deadline and not really thinking through the issues the way that we wanted to think

through." The following anecdote describes the discussion that Dr. Collier led among peers at the Summer institute to help address the barriers they were facing:

> "I tried to host a discussion among all the participants who were there, just kind of asking the question of 'how do we get students to actually care about writing these ethics essays?'"

In this excerpt, Dr. Collier outlines the frustrations that they were having with student attitudes towards ethics assignments. The participant later added that they felt that the Institute "helped a little bit with trying to think through the scope of ethics issues and different types of assignments that can be considered for ethics issues." The workshop served as a platform for faculty to have high-level discussions about sharing their experiences in integrating ethics in their curriculum and various barriers each member was facing.

Faculty engagement with ethics education extended beyond the events organized at Virgnia Tech through initiatives such as the Pathways Summer Institute. Members of ASEE, leveraging their professional networks, also contributed to curriculum enhancements. For instance, Dr. Duncan recounted how their department addressed the 'ethical reasoning' requirement:

> "So in [my department], we have case studies, and [the students] do a creative ethics project to explore whatever they wanted to. I actually got that inspiration from a talk at ASEE."

This excerpt illustrates how an interdisciplinary environment such as ASEE can facilitate innovative and multifaceted approaches to ethics instruction. In this section I presented findings that reflect on how workshops and seminars can serve as platforms for dissemination, feedback, and inspiration of pedagogical techniques for integrating ethics into the curriculum. While workshops provide an opportunity for information exchange, the quality of that exchange may be

limited by the experiences of those in attendance. Transitioning from this realization, I now turn the focus on another aspect of faculty development in ethics education: conversations with friends and colleagues. The following section covers another emergent theme pertaining to faculty leveraging the knowledge of their friends and colleagues in a more informal environment.

4.4.4 Conversations with Friends/ Colleagues

Three of the twelve faculty participants emphasized learning from other faculty that they considered friends or colleagues. These conversations served as both mechanisms for knowledge transfer as well as opportunities to learn from the lived experiences of colleagues. For instance, participants who were less knowledgeable about ethics pedagogies were able to from those in their personal network who had experience teaching ethics. One anecdote from Dr. Duncan highlights an ethics resource they use in their class and how they acquired it:

> "It's the JMU eight ethical questions. That's what they call it. The eight key questions… So [a graduate student who also taught the course] got this resource because we had another graduate student who's now a professor at JMU. And he had just gone there. And so, you know, they were still in communication. So then we got this resource."

This excerpt illustrates one mechanism of how knowledge can transfer both across institutional boundaries as well as within a department from those with domain knowledge to those without. While this example emphasizes how ethics teaching resources may transfer between faculty, other participants emphasized learning from the experiences of their friends and colleagues. In this following excerpt, Dr. Kirby describes how friends and colleagues from diverse backgrounds can provide insight into issues such as the 'ethics of design:'

> I'm blessed to have a lot of friends who don't look like me. And so I hear their stories. You may have seen the video of the two guys trying to get the soap dispenser to work. The white guy puts his hand under the soap, and turns it on. Then the black guy puts his hand under [the soap dispenser] and it doesn't. I knew that was the thing long before that video came out. Because I have a black friend and he fussed about it. So those things are, they are foremost; I'm very much aware of them, I pay attention to them.

This passage emphasizes the ethical blind spots that individuals may posses due to our differences and how having diverse networks allow for these blind spots to be brought to the forefront. In this section I presented findings that reflect on how informal connections with other individuals present opportunities for information exchange via pedagogical techniques and the differences in the lived experiences of others. Transitioning to a more formal area, the following section discusses how faculty development occurs in more formal settings, specifically through the undergraduate and graduate experiences of faculty.

4.4.5 Formal Education – Undergraduate or Graduate

Three of the twelve participants emphasized the importance of their own prior experiences through formal education, including both undergraduate and graduate, in the learning of ethics and ethics pedagogical techniques. Of the three participants that discussed formal education on ethics, only one of the three had an undergraduate or graduate degree in an engineering discipline. The other two had backgrounds in English and were brought in by their respective departments to help with the instruction of developing and enhancing engineering professional skills, including technical writing and ethics. The following anecdote describes a text that stuck with Dr. Irwin from their undergraduate curriculum, the participant who had an engineering background:

> And I took a class in my undergrad, that basically took out a lot of the key ones of those and like went a little bit more into depth behind the engineering parts of failure. It was called *Technological Catastrophes*.

The takeaway from this excerpt underscores the significance of forma education in shaping Dr. Irwin's understanding of ethics within their domain specific discipline. Utilizing the textbook, *Technological Catastrophes*, during their undergraduate studies equipped the faculty with in-depth knowledge about ethical dimensions pertaining to engineering challenges, particularly concerning failure analysis. This excerpt highlights how formal education plays a pivotal role in developing a deeper understanding of ethical principles and their applications within academic disciplines.

4.5 Social Network Analysis

To answer the second research question, *What are the personal networks of engineering faculty who develop courses with ethics components*, I utilized the following procedure: the interview and institutional data were combined to generate networks for faculty overall higher education networks, as well as teaching, research, administrative, committee, advice, and mentor networks. Network alters were gathered through two sections of the interview protocol used in research question 1. Faculty were prompted at the beginning of the interview, as they described their experiences with the curriculum reform, to mention their collaborators by name. The last section of the interview explicitly asked faculty to name faculty that they talked to about teaching, research, committee, advice, and mentors. Administrative networks were an emergent network and arose because of participants discussing their various roles at the university, primarily, but not entirely, the participants who had administrative duties. Advice networks largely examined the informal connections faculty went to for advice, while mentor networks examined the more formal

departmental mentorships that existed within the departments. Alter attributes for the network were gathered via publicly available institutional data of the alters.

A combined network map, created in UCINET (UCINET, 2020), was created of the 12 egocentric networks gathered via interview, and is depicted in Figure 3. The egos are denoted by red squares and alters with blue squares. Alters were conceptualized as an individual within higher e education who had contact with the initial faculty member across one of the aforementioned networks. There were no isolates (groups of faculty isolated from the largest network) within the dataset and the most connected alter had connections to four egos. The network consists of 12 egos and 253 alters, with egos having an average of 27 alters (SD = 10.85) and the minimum and maximum number of alters at 11 and 43 respectively.

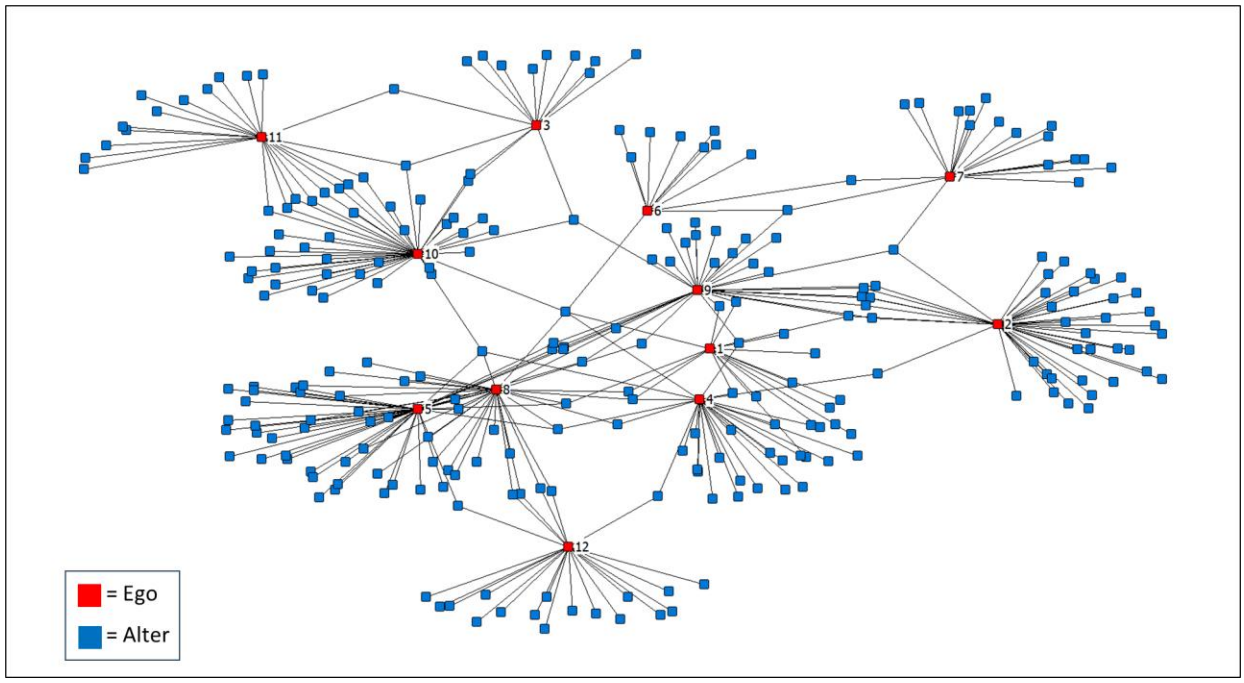

Figure 3. Combined Egocentric Network with Egos (Red) and Alters (Blue)

The overall network consists of 427 ties, with ego having an average of 35.58 (SD = 14.46) ties, depicted in Table 11. Of the 427 ties, there are 323 unique ties between egos and alters. The only network that every ego had alters in was the curriculum reform network, with a total of 61 ties across the 12 egos. Every other network type had at least one ego with no ties of that type. The research, teaching and committees networks had the highest single ego connections with over 20 ties from one ego. The networks with the largest number of ties were the teaching (n = 121), committee (n = 98), research (n = 98), and the curriculum reform (n = 61) networks.

Table 11. Tie Descriptive Statistics

Edge Type	# of Connections	Min	Max	Average	SD
Curriculum Reform	61	2	10	5.08	2.43
Research	66	0	20	5.50	6.27
Teaching	121	0	21	10.08	6.11
Committee	98	0	22	8.17	7.04
Admin	20	0	6	1.67	2.35
Advice	25	0	9	2.08	2.94
Mentorship	36	0	7	3.00	2.73
TOTAL	427	11	59	35.58	14.46

4.5.1 Alter Attributes

Once alters were identified, alter attribute data was gathered as online institutional data. The results from Table 12 indicated that across all networks, a majority of faculty worked primarily with those in the same department at their institution and with administrators. A summary of alter attribute statistics across all network types can be found below in Table 12. Faculty affiliated primarily with alters in the same department and at the same institution (51.4%, n = 166), followed by individuals within the same college at the same institution (22.3%, n = 72) and individuals at the same institution but positioned in a different college (21.7%, n = 70). Concerning the alters' position the highest percentage group across all networks was administrators (31.2%, n = 79),

followed by professors (23.3%, n = 59), teaching professor (20.6%, n = 52), associate professors (18.6%, n = 47), and assistant professors (7.9%, n = 20).

Table 12. Combined Network Alter Attribute Statistics

Variables	**Categories**	**n**	**%**
Departmental Affiliation (323)	Same Department - Same Institution	166	51.4
	Different Department - Same College	72	22.3
	Different College - Same Institution	70	21.7
	Same Discipline - Different Institution	14	4.3
	Different Discipline - Different Institution	5	1.5
Position (253)	Teaching Professor	52	20.6
	Assistant Professor	20	7.9
	Associate Professor	47	18.6
	Professor	59	23.3
	Administrator	79	31.2
	Advisor	10	4.0
	Staff	11	4.3
	Other	10	4.0

Throughout the first half of the interview, when faculty were asked about the process of engaging with the Pathways curriculum reform, participants were asked to mention the collaborators of the curriculum reform by name to create egocentric networks. Results from Table 13 indicated that, at a similar percentage to the overall networks, faculty worked primarily with those in the same department at the same institution. Dissimilar to the overall networks however, faculty work primarily with teaching professors. A summary of curriculum reform alter statistics can be found below in Table 13. Faculty affiliated primarily with alters withing the same department at the same institution (52.5%, n = 32), followed by those at the same institution but in a different college (34%, n = 21), and those in a different department in the same college (11.5%,

n = 7). By position, faculty worked primarily with teaching professors (40.8%, n = 20), administrators (34.7%, n = 17), and professors (14.3%, n = 7) as a part of the curriculum reform process.

Table 13. Curriculum Reform Network Alter Attribute Statistics

Variables	**Categories**	**n**	**%**
Departmental Affiliation (61)	Same Department - Same Institution	32	52.5
	Different Department - Same College	7	11.5
	Different College - Same Institution	21	34.4
	Same Discipline - Different Institution	1	1.6
	Different Discipline - Different Institution	0	0.0
Position (49)	Teaching Professor	20	40.8
	Assistant Professor	4	8.2
	Associate Professor	3	6.1
	Professor	7	14.3
	Administrator	17	34.7
	Advisor	1	2.0
	Staff	2	4.1
	Other	0	0.0

As the setting of this research is Virginia Tech, which is an R1 institution, the research protocol was designed to ask faculty about their research responsibilities, and in doing so, their research collaborators. While the research networks contained a similar number of ties to the curriculum reform network at 66 ties, the research networks were more concentrated within the sample. The number of research collaborations mentioned by participants ranged greatly, with multiple participants having zero, while others had 20 collaborators. Results indicate that faculty worked more evenly across their institutions and outside of the institution with faculty in the same discipline, as well as more frequently with professors and associate professors than in other

networks. A summary of the research networks alter ties by departmental affiliation and position can be found below in Table 14. Faculty affiliated primarily with alters within the same department at the same institution (36.4%, n = 24), followed by alters in different colleges at the same institution (25.8%, n = 17), those in different departments within their college (18.2%, n = 12), and alters at different institutions but in the same discipline (15.2%, n = 10). By position, participants' research collaborators were largely professors (30.5%, n = 18), administrators (28.8%, n = 17), and associate professors (23.7%, n = 14).

Table 14. Research Network Alter Attribute Statistics

Variables	**Categories**	**n**	**%**
Departmental Affiliation (66)	Same Department - Same Institution	24	36.4
	Different Department - Same College	12	18.2
	Different College - Same Institution	17	25.8
	Same Discipline - Different Institution	10	15.2
	Different Discipline - Different Institution	3	4.5
Position (59)	Teaching Professor	9	15.3
	Assistant Professor	8	13.6
	Associate Professor	14	23.7
	Professor	18	30.5
	Administrator	17	28.8
	Advisor	0	0.0
	Staff	1	1.7
	Other	2	3.4

As one of the primary missions of a university is to teach, and because 10 out of 12 of the participants in the study were teaching faculty, teaching networks were examined. Table 15 highlights faculty who discussed teaching primarily within their own department, and largely with teaching professors and administrators. Pertaining to departmental affiliation, alters were

predominantly from the same department at the same institution (47.9%, n = 58), in different departments within the College of Engineering (24%, n = 29), and positioned within different colleges at the same institution (21.5%, n = 26). By position, alters were primarily teaching professors (20.8%, n = 37), administrators (26.7%, n = 32), professors (25.8%, n = 19), and associate professors (12.5%, n = 15).

Table 15. Teaching Network Alter Attribute Statistics

Variables	**Categories**	**n**	**%**
Departmental Affiliation (121)	Same Department - Same Institution	58	47.9
	Different Department - Same College	29	24.0
	Different College - Same Institution	26	21.5
	Same Discipline - Different Institution	6	5.0
	Different Discipline - Different Institution	1	0.8
Position (108)	Teaching Professor	37	30.8
	Assistant Professor	8	6.7
	Associate Professor	15	12.5
	Professor	19	15.8
	Administrator	32	26.7
	Advisor	0	0.0
	Staff	4	3.3
	Other	5	4.2

4.7.2 Multiplex and Isolated Ties

As the study asked about the multiple types of networks that faculty took part in, one of the pieces of this was to examine where the overlap of the networks occurred and where connections between ego and alter existed across only one type of network connections. A multiplex tie exists when an ego and an alter are connected across two or more types of connections (Basov & Brennecke, 2017) and an isolated tie is when a connection between two faculty was only

classified as one network type. A summary of the multiplex networks and isolated ties can be found below in Table 16.

Table 16. Multiplex and Isolated Ties Across Network Types

# of Parallel Edges	Curriculum Reform	Research	Teaching	Committee	Admin	Advice	Mentorship
Curriculum Reform	N = 27, 44%						
Research	8	N = 38, 57%					
Teaching	20	19	N = 64, 53%				
Committee	13	5	14	N = 70, 71%			
Admin	1	0	0	0	N = 19, 95%		
Advice	0	3	7	1	0	N = 14, 60%	
Mentorship	8	2	18	9	0	3	N = 11, 31%

The most frequent multiplex ties were between curriculum reform and teaching (N = 20), teaching and research (N = 19), teaching and mentorship (N = 18), teaching and committees (N = 14), and pathways and committees (N = 13). Isolated ties were identified most prominently in administrative (N = 19, 95%) and committee networks (N = 70, 71%), and were least frequent in mentorship (N = 11, 31%) and curriculum reform networks (N = 27, 44%). In Table 16, parallel ties can be seen at the intersections of two different network types, while isolated ties can be seen

at the intersection of a network type with itself. The percentage of isolated ties was determined by dividing the raw number of isolated ties by the number of total ties for that network type.

4.7.3 Departmental Affiliation and Position Homophily

Homophily (ego-alter similarity) was measured using E-Net (S. Borgatti P., 2006). The E-I Index was used to calculate homophily, which is a measure of similarities of alters to an ego (Halgin & Borgatti, 2012). As the E-I index (Krackhardt & Stern, 1988) is a reverse measure of homophily, a larger number, greater than zero, indicates heterophily (Perry et al., 2018c). A summary of the E-I indexes for alter departmental affiliation and position can be found below in Table 17.

Table 17. Measure of homophily via E-I Index

E-I Index	Departmental Affiliation	Position
Whole Network	-0.015	0.617
Pathways	-0.049	0.263
Research	0.273	0.759
Teaching	0.033	0.431

By departmental affiliation, there was a slight tendency for faculty to associate with people outside their department across research (0.273) and teaching networks (0.033), and a slightly homophilous tendency within curriculum reform networks (-0.049). The most heterophilous network by position was the research network (0.759), followed by the teaching network (0.431), and the curriculum reform network (0.263). Eighteen ties from the whole network were removed in the calculation of the E-I index as they were both External and Internal. It should be noted that inflates the E-I index for alter position across the whole network. Similarly, 27 faculty with

multiple external ties were each coded as one external individual as the goal of the E-I index is to examine the homogeneity of the people in each network, not all positions that each alter has.

4.6 Summary

To answer the first research question of this dissertation, *What are the experiences of engineering faculty in developing courses with ethics components*, I conducted faculty interviews with twelve faculty in the College of Engineering at Virgnia Tech who developed and revised courses as a part of the Pathways curriculum reform. Through the thematic coding of twelve faculty interviews, four major themes were identified as components of faculty experiences engaging with a university-wide curriculum reform. Faculty described the: 1) resource- and influence-driven barriers they faced in attempting to revise their curricula, 2) their perspectives on the ethical culture of various organizational units within Virginia Tech, 3) the institutional incentives and resources that faculty leveraged to drive the process of curriculum development, and 4) the methods that faculty leveraged learn about engineering ethics and its associated pedagogies.

To answer the second research question of this dissertation, *What are the personal networks of engineering faculty who develop courses with ethics components*, I gathered alter data across seven types of networks from semi-structured interviews with faculty: 1) curriculum reform, 2) research, 3) teaching, 4) committee, 5) administrative, 6) mentorship, and 7) advice networks. By integrating the alter data gathered via semi-structured interviews with publicly available institutional data on position and departmental affiliations I examined the descriptive statistics of alters across network types, the multiplexity of the faculty networks, and the homophilic tendencies of faculty across department and affiliation.

Chapter 5 – Discussion, Limitations, and Implications

In this chapter, I delve into a comprehensive discussion that bridges the gap between theoretical insights and the findings, thereby elucidating the updated theoretical framework that underpins this study. By synthesizing key concepts from various disciplines, I refine our understanding of the implementation of ethics within the Pathways curriculum reform, paving the way for nuanced interpretations and implications. Crucially, this discussion not only reveals the theoretical evolution of the research but also underscores its pertinence to the broader scholarly discourse. Through a critical engagement with relevant literature, I contextualize my dissertation findings within the existing body of knowledge, highlighting both the congruencies and divergences. By doing so, I not only contribute to the advancement of knowledge but also provide valuable insights for future research.

5.1 Modifying Lattuca and Stark's (2009) Academic Plan Model

To address Research Question 1, *What are the experiences of engineering faculty in developing courses with ethics components*, I examined the experiences of faculty within Virginia Tech's Pathways general education curriculum through the lens of the Academic Plan Model. The Academic Plan Model proposed by Lattuca and Stark (2009) provides a comprehensive framework for understanding and implementing curriculum change in higher education institutions. One component of the framework that differentiates it from other frameworks are the paths which outline the iterative nature of the curriculum and emphasize avenues for curriculum reform. To effectively navigate the complexities of curriculum change, it is imperative to address various barriers and challenges that arise during the process. This addition to the Academic Plan Model aims to highlight and integrate key themes related to barriers, incentives, faculty perceptions,

resources, and faculty learning, thereby providing change agents with a more nuanced understanding of the factors influencing successful curriculum change initiatives.

In the modification to the Academic Plan, presented in Figure 4 below (also found in Appendix D), I outline influence-driven and resource-driven barriers not as tangible elements of curriculum reform, but as an domain within the framework in which barriers may present themselves as a result of the specific elements of curriculum reform, each of which align with one of the Paths presented in the original Academic Plan.

1. Influence-Barriers**:** This category encompasses incentives and faculty perceptions, which elucidate how influencing groups seek to shape the educational environment and how instructors may respond to such influences. By acknowledging and addressing these factors within the Academic Plan Model, change agents can better anticipate resistance or skepticism from faculty members and strategically engage with stakeholders to garner support for curriculum change efforts.
2. Resource-Driven Barriers: Resources and faculty learning fall under this umbrella, offering insights into avenues for instructors to assess and adapt to the educational environment. Integrating considerations of resource availability and faculty development opportunities into the Academic Plan Model allows change agents to identify potential constraints and proactively implement strategies to mitigate resource-related barriers to change.

As a result of themes emerging from the results of this study, I have added two elements to Path B to examine how resource-driven barriers may arise, namely Resources and Faculty Learning. As a result of changing educational outcomes, three faculty described feeling unprepared to teach ethics within the classroom. The feeling of unpreparedness required faculty to both find and leverage institutional and personal resources to adjust their courses. In the case of two faculty,

resources were all faculty required to adjust the educational environment, as was the case for faculty who were updating case studies within their course. However, two faculty were unfamiliar with how to teach ethics, which in addition to finding the appropriate resources, also required them to address the knowledge gap through learning and make the necessary adjustments for their course.

In line with the findings of this research, I have also added two elements to examine influence-driven barriers that may arise along Path C, namely Incentives and Faculty Perceptions. My findings highlight that influencing groups provided incentives for faculty within the Pathways curriculum reform. How participants perceived both the incentives and the organizations providing them in part influenced how faculty leverage those incentives. Specifically, incentives were often provided as resources (i.e. Pathways grants), which faculty can leverage to evaluate and adjust the educational environment.

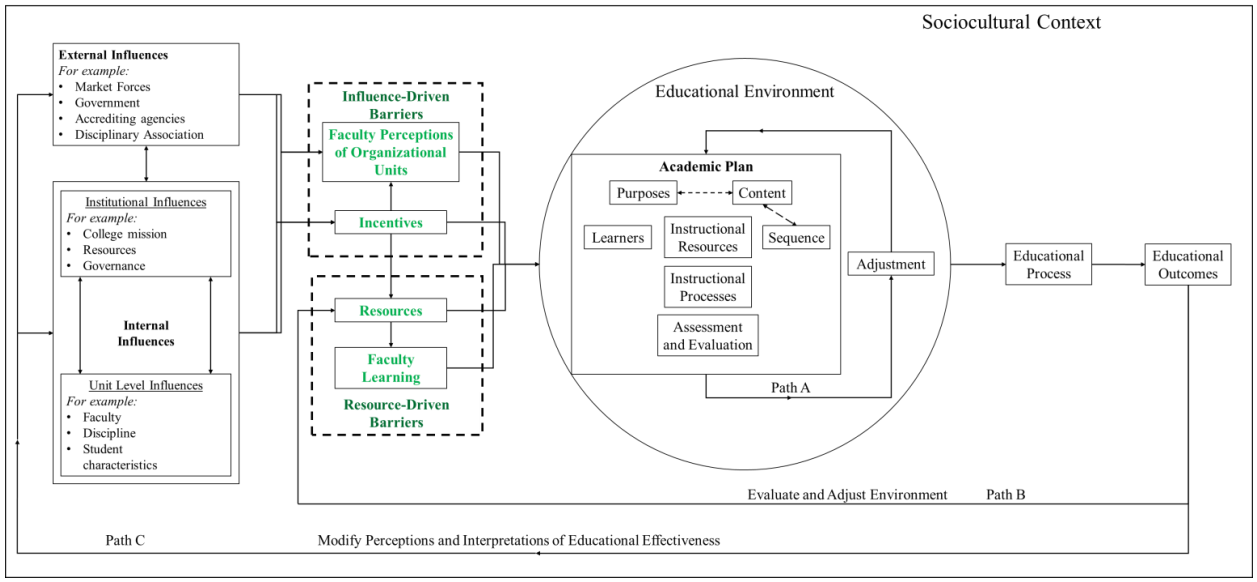

Figure 4. Process-oriented modification to Lattuca and Stark's (2009) Academic Plan Model

By leveraging existing resources and incentives, faculty were able to evaluate and adjust the educational environment by addressing the institutional and external influencing groups' perceptions of their courses. Through these mechanisms, faculty were able to overcome both resource and influence driven barriers that presented themselves throughout the curriculum reform process. To examine the themes highlighted in the process-oriented modification to the Academic Plan in more detail, the next few sections examine the pertinence of my findings to the rest of the academic literature.

5.2 Pertinence to Literature

The following three sections address the pertinence of my dissertation findings to the academic literature examining curricular change, engineering ethics education, and social network analysis. The first two sections (5.2.1-5.2.2) aim to address the pertinence of the first research question to literature, specifically as it pertains to faculty experiences within the Pathways curriculum reform. The third section (5.2.3) aims to address the pertinence of the second research question to the literature, specifically in examining the social networks of faculty.

5.2.1 Barriers to Change

One significant challenge frequently raised from the participants across the "Resource-driven" theme was the 'Packed Curriculum.' Despite faculty support for change and enthusiasm for adopting new teaching methods or integrating fresh material, time constraints within courses often impede these efforts. Scholars (Brownell & Tanner, 2012; S. N. Davis & Jacobsen, 2014; Hills et al., 2022) too have highlighted that implementing change demands substantial time and effort. Trimming content, rearranging sequences, and developing new course material within limited class time pose considerable difficulties. While both the 'Packed Curriculum' and the 'Pathways Revision Process' revolve around time constraints, the latter specifically emphasizes the

time commitment required in implementing curriculum changes. In alignment with Rogers (2003), results from this research indicate that time commitments may hinder the adoption rate of change initiatives, which is furth accentuated by the average 60-hour workload of faculty (Zibrowski et al., 2008). While faculty described the curriculum as full, it should be noted that they were still able to find content to cut to make room for the new Pathways content and to meet the needs of the State/college to cut credits. This may indicate that faculty perceptions of the packed curriculum may be inflated by motivations such as not wanting to cut their course.

The 'Faculty Preparedness' and ‘Inexperience Assessing Ethics’ themes focus on the time faculty and graduate teaching assistants (GTAs) required for course preparation. Aligning with Collinson and Cook’s (2001) insights, my study found that faculty often feel unprepared for curricular changes, requiring additional time to acquire necessary skills. This study found that faculty felt that those assessing ethical content and advanced discourse, necessitating future training, which resonates with prior research (Shadle et al., 2017; Hills et al., 2022) Additionally, aligning with the work of (Walder, 2015), faculty found that large class sizes also hindered specific assessments needed for Evidence-Based Instructional Practices, specifically in the assessment of writing assignments.

The resource-driven barriers identified by participants were centered around a perceived lack of time and funding to revise the curriculum. While faculty have a large amount of autonomy over their classroom, students, administrators, and engineering professionals all hold varying levels of influence over the classroom (Lattuca & Stark, 2009).

This study found that faculty perceived students to be both less familiar with ethics material and engage with it less, which corroborates prior findings (Boté-Vericad, 2021; Hills et al., 2022). Resonating with the work of Lönngren (2021), results underscore that when faculty emphasize the

importance of ethics assignments, students were more receptive to the changes made in the classroom. Aligning with Hess et al.'s (2020) insights results from this study show that while written assignments are among the most prominent instructional strategies among engineering educators, the quality of their implementation is important, as inadequate incorporation may diminish the value of the ethics material.

This study found that multiple instructors were unwilling to facilitate knowledge transfer to the participants taking over their course. Similarly, this research found that departments were hesitant to accommodate technical writing courses in a department in which many of the faculty had not taken one themselves. Expanding on these findings, Shadle (2017) underscores that barriers concerning unsupportive colleagues can be caused by colleagues' lack of time and understanding of the importance of discourse and ethics in the curriculum. In alignment with this research's findings, Austin (2011) and Volkwein et al. (2004) also reported departmental cultures that incentivize research through tenure and promotion also disincentivize faculty that prioritize teaching and curriculum revision.

At Virginia Tech, the competition for students was felt by engineering faculty as a push to reduce credits from college and state-level influences at the same time the Pathways curriculum reform was under way. This expands on the study completed by of Brostrom and the colleagues (2021), who found that as universities have shifted to a business model from public service, competition among universities has led them to differentiate themselves from other similar more elite institutions. Specifically, this research highlights the competition between higher education institutions for undergraduate admissions and university ranking, which is corroborated by prior findings (Enders, 2014; Wall Bortz et al., 2020).

Regarding the influence of industry on the curriculum, participants worried about the impacts of students having negative experiences concerning ethics through internships, as the emphasis in industry contradicted that in academia. These findings align with Austin (2011), who found that students who participate in internships and co-ops with industry may become less receptive to the teaching priorities in academia. Similarly, results indicated instructors in specific disciplines were also attempting to reduce professional engineers' negative perception of ethics, which is corroborated by prior work (Lönngren, 2021).

This study also examined faculty perceptions of various institutional organizations' (i.e., department, college, university) culture of ethics. Findings from this dissertation found that when research faculty perceive that their department more consistently values time spent on research, faculty may be disinclined to focus on improving teaching, which aligns with prior research (Shadle et al., 2017). Similarly, findings corroborates that if teaching faculty are not surrounded by colleagues teaching similar content areas, they may feel isolated (Boada, 2021). When asked about the college's culture of ethics, faculty instead focused on the departmental and institutional level, suggesting the diminished role of the college in setting a culture of ethics, corroborating prior research (Polmear et al., 2021). Regarding the culture of ethics at the university level, while participants perceived the importance of the Pathways curriculum reform to be legitimate, participants identified a lack of consistency across the university's budget actions, internal communications and institutional commitment towards ethics. This finding is in alignment with the work of Holland (2019) who found that when faculty perceive their institution's actions towards ethics as consistent, it increases faculty trust of the institution's commitment to ethics.

5.2.2 Drivers for Change

While literature examining curricular change in higher education primarily focuses on the barriers to successful change, this research also examined the resources, incentives, and change strategies that faculty leveraged as a part of the Pathways university-wide curriculum reform to successfully implement change.

Resource deprivation, encompassing constraints on both time and financial support, emerges as a significant impediment to curricular change initiatives, a finding consistent with prior research (S. N. Davis & Jacobsen, 2014). My study delves into the effectiveness of addressing this challenge through the provision of financial incentives, as exemplified by the examination of curriculum reform via Pathways Grants. Aligning with Austin's (2011) insights, findings indicate that such incentives can make faculty feel that their time is valued when enhancing their teaching practices. Furthermore, this research underscores the multifaceted nature of resources, with faculty emphasizing their prior experiences as invaluable assets for curriculum reform. This finding resonates with Polmear's (2019) exploration of the efficacy of leveraging prior industry work as a resource for integrating real-world applications into the classroom. Moreover, my study results align with Polmear et al. (2022), demonstrating how faculty draw upon their formal educational experiences, gained through both undergraduate and graduate courses, to enrich their teaching methodologies in the classroom. In addition to prior knowledge and experiences, this research found that previously existed resources such as committees can be leveraged by institutions and change leaders to alleviate resource requirements of change initiatives, such as through curriculum and ABET accreditation committees.

My dissertation also explored how faculty utilized their personal networks as a valuable resource for driving curriculum change. This finding resonates with the emphasis placed by Cross et al. (2021) on the significance of collaborative environments in fostering successful curriculum

reform initiatives. My dissertation findings suggest that instructional programs, workshops, and conferences served as platforms for faculty to gain ethics competencies. Research has found similar findings that institutional instructional programs (K. J. Cross et al., 2021), workshops (Hochstedt et al., 2015), and conferences (Walczak et al., 2010) emerge as key avenues through which faculty engage in collaborative practices and independently acquire knowledge.

Moreover, this study aligns with Borrego and Henderson's (2014) assertion regarding the critical role of external and institutional drivers in instigating curriculum change. Within the context of the Pathways curriculum reform, faculty underscored the instrumental role of institutional governance mechanisms, such as peer review processes and department-level committee reviews, in facilitating the curriculum reform process (Teoh et al., 2016). These initiatives represent tangible forms of support from both departmental and university levels, underscoring the necessity of aligning administrative expectations at various organizational levels to effectively support faculty-led initiatives (Davis & Jacobsen, 2014).

5.2.3 Social Network Analysis

The following section provides discussion of how findings from my dissertation relate to pertinent literature to answer the second research question, *What are the personal networks of engineering faculty who develop courses with ethics components?* As an extension to the examination of faculty collaborations as a change strategy for curriculum reform, egocentrics social networks of participants were examined to determine the role of faculty connections in curriculum reform.

One of the many barriers to the diffusion of information in engineering education is that disciplinary barriers lead to the siloing of information (Wankat, 2011; Xian & Madhavan, 2014). Contradicting the prevalence of siloing in engineering education, results from this research found

that roughly half of all faculty collaborations across seven network types were outside of disciplinary boundaries. The number of interdisciplinary connections across the sample indicates the importance of social networks in examining informal social structures of faculty to examine curricular change (Quardokus & Henderson, 2015).

Concerning faculty collaborations within the curriculum reform, research has shown that departments hold significant control over the design of their courses. Aligning with this study's findings, prior research has found that curriculum structure and pedagogical changes are the most productive at the department level (Quardokus and Henderson, 2015), which leads to faculty working on department-level pedagogical change to collaborate primarily with other faculty in their department.

Regarding the compositional characteristics of teaching-focused networks, faculty primarily worked with faculty within their department and teaching faculty, which is consistent with other literature (Pataraia et al., 2014; Hur et al., 2023). However, differences arose as teaching-focused networks of faculty in this study also had a large percentage of connections within the university but outside the college. One possible explanation for this discrepancy is due to the large number of administrators in the dataset, which includes domain specialists and teaching centers outside of the college of engineering, in organizational units that support faculty professional development (Brown et al., 2015). The difference could also be explained by institutional structure, as smaller universities may not have entire organizational units dedicated to the professional development of faculty.

Regardless of the causality and temporal order that the parallel connections were created in, results indicate that the egos-alter pairs within the Pathways curriculum reform network had parallel ties with teaching, research, and mentorship networks. Parallel ties existing across multiple

networks (multiplexity) indicate stronger social ties between actors (Kempe et al., 2003; Basov & Brennecke, 2017). The most common multiplex network in the results was between the curriculum reform and teaching networks, which aligns with the sample consisting primarily of teaching faculty who were a part of the Pathways curriculum reform. Additionally, 27 actor-pairs were connected via only curriculum reform ties. The lack of multiplex ties across the actor-pairs indicates that curriculum reform is another method to initiate tie formation and does not need to rely on preexisting ties to form new ties. This research serves as a proof of concept for using social networks as a method for identifying preexisting ties to facilitate connection forming in curriculum reform and examining the impact of a curriculum within an organization network. Administrative networks were show to be largely isolated in nature, 95%, meaning that administrative connections did not translate to meaningful connections in other activities across the university. Regarding the parallel ties of the mentorship network, they were significantly more parallel ties with the teaching network when compared to the research network. This is indicative of the nature of the prior training for faculty in higher education, insofar that there is a significant lack of preparation for instruction for faculty when compared to research, thus requiring more mentorship for faculty.

Faculty egocentric teaching networks were found to be heterophilous by both departmental affiliation and position. While other research has found heterophily across faculty positions (Hur et al., 2023), the teaching networks of this study were more heterophilous for departmental affiliation, indicating more interdisciplinarity. One possible reason for this discrepancy is the interdisciplinary nature of the incentives provided by the university, sparking interdisciplinary discussions of teaching. Heterophilous networks can expand faculty members' opportunities to explore new teaching pedagogies (Pataraia et al., 2014). Research networks were similarly heterophilous across both position and departmental affiliation. As most of the participants were

teaching faculty, research supports that engineering educators would collaborate with faculty who are incentivized to conduct research (i.e., professors, associate professors), leading to this samples' heterophilous networks (Brownell & Tanner, 2012).

5.3 Summary of Discussion

To make sense of the broader themes that emerged from this research, I mapped the central themes from the findings to Lattuca and Stark's Academic Plan Model, with the purpose of underscoring the Paths of curriculum reform that exist with a sociocultural context. I then went to examine how the results of the study related to the pertinent literature of the field, examining faculty perceptions of barriers to change and drivers for change. Finally, I examined the importance of faculty connections in overcoming barriers to curriculum reform by leveraging the knowledge of their other pre-existing ties.

5.4 Limitations

While purposeful in its selection, the study population consisted of faculty who were currently teaching ethics in engineering courses and the sample was made of those willing to conduct an interview. Because of the purposeful sampling, there is a bias within the study's population towards faculty who value engineering ethics and education research. Despite necessarily having ethics within their course curriculum, individuals who perceived ethics to exist outside of their technical expertise might have elected to not participate in in this research (Newberry, 2004). Neither the population nor the sample are likely representative of the engineering faculty at large at Virginia Tech. However, this finding is not detrimental to the study as the purpose is not to make claims about the ubiquity of ethics in the engineering curriculum, but to examine the barriers that arise when attempting to do so. Specifically, the lack of research faculty within the sample highlights that existing incentives in tenure and promotion practices do

not value for this type of courses within the engineering curriculum. Additionally, the sample consisted of entirely white faculty and ten of the twelve faculty were teaching faculty. Each of these sample demographics poses a challenge to generalizing the findings of this study. However, the sample highlights broader issues within the engineering profession regarding the diversity of faculty and the priority of departments in teaching ethics.

With an average interview length of 71 minutes, it was impossible to capture the full experiences of faculty of the curriculum reform. Additionally, as interviews sometimes took place three years after the integration of the Pathways curriculum reform in participant courses, there were both aspects of the revision process that faculty were unable to recall. Similar limitations arise when collecting social network data, especially across a multitude of networks, is the measurement error and missing data due to faculty recall (Carolan, 2014). Due to the temporal limitations of the interviews in this study, it was impossible to assess the strength of faculty ties within specific networks. Therefore, the strength of faculty ties was instead captured through examining the multiplexity of faculty networks.

Another limitation of this research is in how the research evolved over time. When this research was first ideated and initial interviews had been conducted, the original plans for the research were to conduct short interviews with faculty alters to examine homophilic faculty perceptions towards ethics in the curriculum. However, alters responded to both surveys and interview solicitations at a rate of less than 5% with not one participant having more than 50% of their alters respond. Due to the response rate, faculty subcultures could not be examined more thoroughly.

A fourth limitation of this study permeates the findings of the research. While this study did not utilize a mental models methodology, the findings of this study are similarly the

participants internal representations of systems and processes, specifically of the Pathways curriculum reform process, which influence the curricular and pedagogical decisions of faculty members (Chew et al., 2022; Johnson-Laird, 1995; Khemlani et al., 2014). While the themes identified in the study were all experiences of the faculty, they are only a subset of the possible existing themes within the examination of the Pathways curriculum reform. The results of this study should not be viewed as comprehensive in nature, but rather as a description of themes that were identified within this specific empirical research.

Finally, despite its strengths, the case study methodology is not without its limitations. One of the primary constraints is the potential lack of generalizability inherent in single-case designs. Because case studies focus on a specific context or situation, the findings may not be easily transferable to other settings or populations. However, as the detailed process for the interviews and thematic coding was documented, the findings might be transferrable to other institutions (Yin, 2003). Additionally, there is a risk of researcher's bias, as the interpretation of data in case studies is highly subjective and influenced by the researcher's perspectives and experiences. To mitigate researcher's bias, I utilized interrater reliability to improve the reliability of the emergent themes. Furthermore, case studies often involve a small sample size, which may limit the breadth and depth of the findings. This can pose challenges in capturing the full complexity of the phenomenon under investigation and may restrict the generalizability of the results. Lastly, case studies are typically time-consuming and resource-intensive, requiring extensive data collection and analysis, which may not always be feasible in certain research contexts. Despite these limitations, case studies remain a valuable research approach, particularly in exploring complex phenomena within specific contexts and generating rich, in-depth insights. Adopting a case study methodology allowed this dissertation to explore the Pathways curriculum revision across the College of Engineering by

examining the experiences and networks of 12 faculty more in depth while also drawing comparisons between them.

5.5 Study Implications

This dissertation used a case study approach to examine faculty experiences amidst a prescriptive, university-wide curriculum reform to incorporate ethical reasoning and intercultural/global across the curriculum. While this research examines the perspectives of faculty and administrators, the results emphasize the influence of all actors over each other within a curriculum reform that have been reported previously (Lattuca & Stark, 2009; Katz & Knight, 2017; Polmear et al., 2020). Results from this dissertation illuminated implications for faculty planning courses that incorporated ethics, administrators in charge of outlining the implementation of ethics into an engineering curriculum, change agents instituting change initiatives, and engineering ethics education researchers assessing change initiatives.

Engineering Educators – This research highlights the multitude of resources available to faculty to aid them in engaging with ethics in the engineering curriculum. While results found barriers to curriculum reform from the individual faculty to the institutional level, they also highlighted that resources were similarly available from an individual learning perspective to workshops across the institution and beyond. While some of the resources and incentives outlined as themes in this research were limited to the Pathways curriculum reform, others are available to any engineering educator attempting to integrate ethics within their curriculum. Engineering educators responsible for ethics instruction should seek out resources from a number of sources and mediums to expand their understanding of ethics beyond their specific engineering discipline.

Specifically, literature across disciplines such engineering, philosophy, and law were identified by faculty, which offer complementary perspectives on the importance of ethics for

professional engineers. Additionally, engineering educators should seek out educational conferences such as the American Society for Engineering Education (ASEE), the European Society for Engineering Education (SEFI), and the Association for Practical and Professional Ethics (APPE) occur yearly, which serve as platforms for discourse on ethics and pedagogical techniques. Participants also identified the importance of colleagues within curriculum reform as resources. From informal discussions with friends to formal connections made through the attendance of workshops, this research underscores the importance for faculty to collaborate and discuss with faculty in their home departments to further develop ethics in their courses.

University Administrators – For administrators at the department level, results emphasized the utility of administrators in the incorporation of ethics within the engineering curriculum. As administrators have a broader understanding of the discipline's curriculum, they are uniquely positioned to serve as coordinators in the implementation of ethics across the curriculum. Additionally, the results stressed that faculty could identify when they felt that ethics was not being similarly valued across university initiatives, messaging, and budget. Despite the responsibilities of university initiatives falling on different administrative groups, faculty may associate all institutional decisions with the monolith of the university. Administrators should attempt to align values across initiatives, else faculty may not perceive a new initiative as genuine or sustainable – an implication spinning out of one the study findings, also in corroboration with findings of Holland's (2019) study. Regarding the efficacy of the Pathways initiative to integrate ethics instruction across the university, and specifically the college of engineering, I would recommend implementing a program similar in nature to the Pathways workshops in which faculty from across the university could learn from one another and share their perspectives on ethics and ethics instruction. Not only did this resource provide an platform for engineering faculty to broaden

their understanding of academic ethics, but also provided them with avenues for future teaching collaborations.

Change Leaders – The research highlighted the tendency for faculty to discuss both teaching and pedagogical curriculum reforms with other teaching faculty. Similarly, the results emphasized the importance of leveraging existing administrative units in universities geared towards pedagogy and faculty professional development. Additionally, this research asserts the notion that engineering faculty perceive the existence of multiple sub-cultures of ethics within academia. Sub-cultures were noted by faculty at the university, college, and department level. Therefore, it is important for change leaders to instituting change initiatives to identify subgroups of faculty when leading a change initiative across a diverse set of actors. By identifying subgroups of faculty with differing views of ethics, change leaders can target initiatives to incentivize faculty subgroups that may serve as barriers to curriculum reform. For change leaders at the college or university level overseeing curriculum change, results suggest the importance of clear communication avenues to both the individuals in charge of coordinating a change as well as those responsible for instituting change at the course-level. Additionally, as faculty may join into an initiative after the initial buy-in period, it is important to make resources and incentives more continuously available.

Engineering Education Researchers – The outcomes of this study hold significant implications for researchers in the field of engineering education. By adopting a case study methodology, this research offers valuable insights into the dynamics of curriculum reform within engineering programs. Through my modification of the Lattuca and Stark (2009) Academic Plan framework, I not only unveil the challenges encountered during the process but also provide a blueprint for future investigations into the intricacies of change management within engineering

education contexts. Furthermore, the study underscores the importance of leveraging social networks as a lens through which to understand faculty interactions within engineering departments. Specifically, the concept of network multiplexity emerges as a potent tool for assessing the strength and interconnectedness of faculty ties, thus offering a nuanced perspective on collaborative efforts within engineering academia. Moreover, this research serves as a pioneering endeavor in demonstrating the applicability of Social Network Analysis (SNA) in studying institutional change within engineering education. By showcasing the efficacy of SNA in elucidating faculty dynamics and their implications for curriculum reform, this study sets a precedent for future investigations in the field.

Considering these implications, it is imperative for engineering education researchers to recognize the pivotal role of leadership and advocacy in driving curriculum innovation. Empowering change agents and academic leaders within engineering departments to champion the importance of adaptability and innovation can catalyze meaningful transformations in engineering education, thereby ensuring its relevance and efficacy in an ever-evolving technological landscape.

Chapter 6 – Conclusions and Future Work

6.1 Conclusions

This research was initiated by a desire to understand the experiences of engineering faculty taking part in the Pathways general education curriculum reform at Virginia Tech. To understand the theoretical underpinning of the change initiative, I started by examining the current state of literature of engineering ethics education. Through this effort, I found a lack of consensus on the implementation of ethics in the curriculum. As I examined recent change initiatives to incorporate ethics into the engineering curriculum, I highlighted several barriers that led to mixed results of change initiatives in prior literature. To further explore how researchers were ideating about curricular reform, I reviewed many of the current theoretical frameworks used within engineering education research to examine change. Through this exploration I utilized Lattuca and Stark's (2009) Academic Plan model to frame my study for its emphasis on the complexity of influences that play a role in change and its process-oriented approach. I used a descriptive case study to answer the following research questions within the context of the Pathways curriculum reform:

1. What are the experiences of engineering faculty in developing courses with ethics components?
    a. Pertaining to collaboration?
    b. Pertaining to barriers and challenges?
    c. Pertaining to faculty learning?
2. What are the personal networks of engineering faculty who develop courses with ethics components?
    a. Curriculum Reform Networks?
    b. Teaching Networks?

c. Research Networks?

d. Advise/Mentorship Networks?

I addressed the first research question by conducting interviews with twelve faculty in the College of Engineering. Through the inductive and deductive coding of their responses, I framed the answer to the first research question around four central themes: 1) barriers and challenges to curriculum reform, 2) faculty perceptions on the culture of ethics of organizational units (i.e. department, college, university) at Virginia Tech, 3) resources and incentives that faculty leveraged within the curriculum reform, and 4) the process by which faculty learned about ethics and pedagogical techniques to prepare them to teach ethics in their courses.

The process-oriented modification to the Academic Plan framework that I introduced in Chapter 4 represents how the overarching themes identified in the data analysis pertain to the guiding framework of this research. Specifically, results illustrated two types of barriers that faculty perceived within the Pathways curriculum reform, influence-driven and resource-driven barriers. Influence- driven barriers emphasized the disconnect between individual and organizational missions and goals with the instructors in charge of the educational environment. Organizations internal and external to Virginia Tech influenced the curriculum through incentives and policies. Results highlighted how participants perceived the culture of the organizations influenced the instructors' perceptions of the authenticity and sustainability of the curriculum reform. Resource-driven barriers emphasized the need for continued faculty development to teach ethics in the engineering curriculum. Participants described how both incentives from influential organizations and resources of their own finding aided them in learning about ethics and pedagogical techniques to incorporate into the classroom.

Results also emerged when examining the sub-themes of the larger points of inquiry for the study. Faculty highlighted several groups that influenced decision-making across the Pathways curriculum reform, namely students, faculty within their department, the college, state, and industry. Influences ranged from individual's dismissive attitudes towards ethics to the need to collaborate across the curriculum because of a parallel college-wide push to reduce credits. The culture of ethics present in various organizations within Virginia Tech was perceived differently across the participants. Faculty highlighted subcultures of support for ethics within their home departments, the requirement of accreditation at the college-level, and the lack of congruity across university initiatives. Participants cited feeling unprepared to teach ethics while others lacked the necessary pedagogical techniques to teach ethics. However, by leveraging institutional incentives provided by Pathways, conferences, connections with other faculty, and online resources from individuals, faculty developed both their ethics content and their pedagogical techniques.

The second research question of this dissertation explored participants' connections from the Pathways curriculum reform and across several other common types of ties in higher education. To understand the role of faculty connections within the Pathways curriculum reform, during interviews, faculty were asked to describe their connections in the past few years across a multitude of networks: 1) the Pathways curriculum reform, 2) research, 3) teaching, 4) committees, 5) administrative duties, 6) mentorship, and 7) advice.

Results pertaining to the second research question examined the network size, the attributes of faculty alters, network multiplexity, and homophily of participants' egocentric networks. The most prevalent connection type was faculty teaching networks, which aligns with the sample consisting of primarily teaching faculty. Additionally, curriculum reform was the only connection type that all faculty named alters for, highlighting the specialization of faculty roles at the

university, but also the importance of connections in curriculum reform. This research serves as a proof of concept for the use of social network analysis to analyze the strength of faculty ties through the multiplexity of faculty networks. Future research will continue to explore how faculty leverage existing ties across other domains.

Tying research questions 1 and 2 together, this research examined the experiences and networks of engineering faculty participating in the Pathways curriculum reform at Virginia Tech. Results emphasized that despite the number of institutional incentives and resources, faculty still faced many barriers to incorporate ethics within their courses. Faculty stressed the importance of their networks as important sources of ethics knowledge, pedagogical techniques, for their ability to navigate the complexities of a university-wide curriculum reform. Through social networks, I was able to highlight the pivotal, informal, and preexisting connections that faculty leveraged to overcome barriers that arose within the context of the Pathways curriculum reform. In summary the major takeaways from this study are:

1. Faculty felt the influence of various organizations, institutions, and groups of individuals in creating barriers the complicated the Pathways curriculum reform.
2. A prescriptive, university-wide curriculum reform is complex, therefore requiring the cooperation of faculty, department-, and university-level administrators in overcoming the multitude of barriers associated with such a curriculum reform.
3. Faculty highlighted the importance of their personal and professional networks as important resources in overcoming the barriers of curriculum reform.
4. This research serves as a proof of concept for utilizing social network analysis in the evaluation and monitoring of curriculum reforms

6.2 Future Work

Prior research, such as that conducted by Polmear et al. (2021) has examined the personal motivations of faculty in implementing ethics into the engineering curriculum. As the Pathways curriculum reform was largely prescriptive (top-down) in its implementation, faculty motivations were not captured as a part of this study, instead replaced by faculty perceptions of the various organizational units they are a part of within the university. Future work aims to examine the interaction of faculty's personal motivations, influencing groups, and the perceptions of the groups to examine influence-barriers more thoroughly to ethics education.

Additionally, this work studied the perceptions of faculty who incorporate ethics in engineering courses. Three of the participants in this study identified faculty subcultures pertaining to the value of ethics within the curriculum. Future work could examine the perspectives of faculty within a department or other organizational unit who both teach and don't teach ethics, to study subcultures of ethics.

Regarding the utilization of faculty teaching and research networks in this research, future work could explore discrepancies between bibliometric and institutional co-teaching data with faculty perspectives on their teaching and research networks. Discrepancies between publicly available data and faculty perceptions may highlight hidden actors that play a role in teaching and research networks.

In Chapter 3, I offered a discussion between the College of Engineering and the English department to accommodate Pathways requirements via a technical writing course. However, disagreements over the number of students in each class section led to the conversation breaking down and the current implementation of ethics in the curriculum. In future work, I hope to examine how structural barriers such as credit allocation can impact curriculum reform.

Another perspective of curriculum reform that was not examined in this study was that of the students within the Pathways courses. While this research touched on how faculty perceive student attitudes towards ethics, I hope to expand on this in future work by examining student perspectives of ethics across a degree program.

This research limited itself to an examination of barriers and drivers for revising the Academic Plan framework, providing a process-oriented approach for studying curricular change. Future work could examine the connections between barriers and drivers with more granularity, mapping faculty perceptions of barriers and resources that allowed them to overcome barriers. Additionally, future work could extend into the examination of the educational environment and educational process, examining the role of both individual and organizational influences on the specific pedagogical techniques that faculty utilize.

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Appendix A – Interview Protocol

Ice Breaker: Ask how their semester is going =)

Brief Introduction: Introduce myself, discuss interview and interview protocol

Study Description: This study seeks to understand the experiences of engineering faculty involved with the design and teaching of the Pathways courses, specifically those with the ethical reasoning component. We will start out by discussing your current position in the university. We will then transition to talking about the Pathways program, both the course itself and the design of it. We will then step back to discuss your general perceptions of ethical reasoning in engineering, before talking about your personal networks.

Opening Question

1. Could you describe your current roles in the university?

Demographic Questions

2. How long have you been at the university?
    a. How long have you been in academia?
3. What is your current position title?
4. What courses have you taught recently?

Pathways Course Description Questions

5. Could you describe the Pathways course you designed/teach?
    a. What level of students is it for?
    b. In major-out of major students?
6. How have you incorporated ethical reasoning into the course?
    a. Why did you choose to incorporate ethical reasoning in that manner that you did?
7. What kind of experience with ethical reasoning do you expect students to enter your classroom with?
    a. What do you expect them to learn regarding ethical reasoning?

Pathways Design and Teaching Experience Questions

8. What did you first hear about the Pathways Program?
    a. What were your initial perceptions of it?
    b. How have these perceptions changed?
9. How did you come to oversee the developing of the Pathways course?
10. Who did you collaborate with in the creation of the course?
11. What institutional resources did you utilize in the development of the course, if any?
12. Did you have to do research/learning to incorporate ethical reasoning into the course, if so how?
13. What incentives were provided by the university/your department in the creation of the course?
14. What were some of the issues that arose in designing the course?

15. How have you assessed the ethical reasoning component of the course since first designing it and how, if at all, has the component changed?

Engineering Ethics Perceptions Questions

16. What experience with ethical reasoning did you have before implementing it into the course?
17. What aspect of the undergraduate experience do you think plays the most pivotal role in developing students' ethical reasoning skills?
18. What role do you think formal courses play in developing students' ethical reasoning skills?
    a. Engineering courses?
    b. Your course?
19. What would say the culture of the university is towards developing ethical reasoning?
    a. College of Engineering?
    b. Your department?

Network Questions

20. Since the start of the Pathways program, who have you
    a. Talked to about teaching a course?
    b. Talked to about research?
    c. Been on committees with?
    d. Talked to as a mentor/mentee?

Asked for/given advise?

Appendix B – Interview Solicitation

E-mail subject line: Invitation for participating in a study

Dear Virginia Tech [faculty],

You are invited to participate in a research study entitled "A Roadmap for Change: A Mixed Methods Examination of Faculty Networks in the Context of Engineering Ethics Education". The research team is formed by researchers from the Department of Engineering Education and this study will be conducted for a doctoral dissertation for the fulfillment of PhD in Engineering Education.

Investigator(s): Sam Snyder (sams95@vt.edu), Dr. Diana Bairaktarova (dibairak@vt.edu)

The purpose of this project is to examine the influence of ethical perspectives across faculty networks within the College of Engineering

Participation is voluntary. The results will be used for dissertation and eventual journal publications.

One phase of the study includes using faculty interviews to examine faculty perspectives on the various components of the ethics curriculum in the College of Engineering and help construct faculty networks within the college. The project will require 45-60 minutes of your time to complete the interview. The interview can be conducted via Zoom or in person. There is no compensation for your participation. We are recruiting faculty members who have been involved with creating/teaching Pathways courses with the *ethical reasoning* integrative component within the College of Engineering. Would you be interested in participating?

Through the interview process, we will receive identifying information such as departmental and research affiliations. Additionally, we will ask you to identify other faculty members you have collaborated with to help construct your faculty network. The faculty you identify will be contacted to conduct interviews similar to this one. You will not be identified at any point in reaching out to other faculty, and no identifying information will be provided to anyone else within the study. All data will be deidentified before publishing to ensure your anonymity.

This study has been authorized by the Virginia Tech Institutional Review Board (#21-509) and the consent form is attached for your review.

We do hope you will choose to participate in this exciting research. *Please sign below to indicate you have read and agreed to participate in the above study. Once you have signed, please return the signed document via email to Sam Snyder (sams95@vt.edu).*

If you have any questions, please let us know.

Sincerely,

Sam Snyder

Department of Engineering Education

Virginia Tech

If you have questions about the research study, please contact Sam Snyder of the research team at sams95@vt.edu.

Appendix C – Consent Form

Information Sheet for Participation in a Research Study

Principal Investigators: Sam Snyder, Dr. Diana Bairaktarova

IRB 21-509 - A Roadmap for Change - A mixed methods examination of faculty networks in the context of engineering ethics education

You are invited to participate in a research study. This form includes information about the study and contact information if you have any questions.

"I am a graduate Engineering Education student at Virginia Tech, and I am conducting this research as part of my dissertation."

WHAT SHOULD I KNOW?

If you decide to participate in this study, you will complete an interview. *As part of the study, you will participate in an interview that examines faculty perspectives on the various components of the ethics curriculum in the College of Engineering and help construct faculty networks within the college by asking about connections of the faculty member. The project will require 45-60 minutes of your time to complete the interview. The interview can be conducted via Zoom or in person. There is no compensation for your participation. The interview can be conducted via Zoom or in person and will be audio-recorded via a recording device or the Zoom recording option.*
We do not anticipate any risks from completing this study.

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

CONFIDENTIALITY

We will do our best to protect the confidentiality of the information we gather from you, but we cannot guarantee 100% confidentiality.

Any data collected during this research study will be kept confidential by the researchers. Your interview will be audio-recorded using a digital recorder and then transcribed. The researchers will code the transcripts using a pseudonym (false name). The recordings will be uploaded to a secure password-protected computer in the researcher's office. The researchers will maintain a list that includes a key to the code. The master key and the recordings will be stored for 3 years after the study has been completed and then destroyed. Additionally, we will ask you to identify other faculty members you have collaborated with to help construct your faculty network. You will not be identified at any point in reaching out to other faculty, and no identifying information will be provided to anyone else within the study.

WHO CAN I TALK TO?

If you have any questions or concerns about the research, please feel free to contact Sam Snyder (sams95@vt.edu). You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact the Virginia Tech HRPP Office at 540-231-3732 (irb@vt.edu).

Please sign below to indicate you have read and agreed to participate in the above study. Once you have signed, please return the signed document via email to Sam Snyder (sams95@vt.edu).

_____

Signature

Please print out a copy of this information sheet for your records.

Appendix D. Process-oriented Modification to Lattuca and Stark's (2009) Academic Plan