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Exploring the Social Processes of Ethics in Student Engineering Design Teams

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Exploring the Social Processes of Ethics in Student Engineering Design Teams

Engineering and engineering design are increasingly recognized as a social activity[1] and require interaction and collaboration with diverse groups of people. Design has been defined as "a social process in which individual object worlds interact, and design parameters and ideas are negotiated,"[2] as well as "the complex processes of inquiry and learning that designers perform in a systems context, making decisions as they proceed, often working collaboratively on teams in a social process, and 'speaking' several languages with each other (and to themselves)."[3] These definitions reflect the complex social and communicative processes that need to be unraveled to offer a complete understanding. While student design contexts differ in important ways from professional practice,[4-5] the program-based engineering education context represents an important space for novice engineers to learn about and develop understandings that will impact their future engagement in design.

In the context of design, there are many different values, such as innovation or a primary concern for safety, that guide design decisions and processes and can impact how designers think about the ethical issues related to their designs and the implications of their "everyday" ethical decisions. This is complicated as ethics is often approached as an outcome (an ethical product or use of a product), or a major decision premise within design work (such as choosing to falsify data or failing to acknowledge a person's contributions). It is rarely recognized as an *inherent component of the design process*, or an everyday occurrence that affects all the decisions a designer makes.[6] Furthermore, ethics in a team-based context is even more complex, as it requires the interaction and negotiation of several people often from vastly different backgrounds. The moral autonomy in individual ethical reasoning is likely to be affected by others in the team context. Typically in the team context, one has to justify one's moral choices and consider why others should accept one's individual proposition and engage in negotiation with teammates,[7] rather than making and executing decisions autonomously. Team member interactions, discussions, and individual evaluations of each other and the design process itself, all contribute to both individual ethical behavior and team-level ethical reasoning and decision-making.

In this paper we present a communicative approach to examining these complex social and relational interactions among team members in engineering design teams that utilizes social network analysis to illuminate the interaction structures that emerged across various domains such as technical expertise, programmatic knowledge, and ethics, as teams engage with each other throughout the design process. Communication becomes an essential ingredient in a team-based work environment, necessitating negotiation, collaboration, and decision-making between people of often diverse backgrounds. While communication is often conceived as the verbal messages that convey information, it also includes the relations individuals form as they interact and collaborate, as well as the perceptions and attitudes formed between members of a team. Team member communication is an essential component of group performance and a major determinant of productivity and team success.[8,9] A positive team climate affects decision-making, creativity, and the effectiveness of problem-solving processes in teams.[10] The precise role of communication in a group's effectiveness is still contested,[11] making studies that examine this process in depth of particular value.

When considering ethical reasoning in a team context, the social processes underlying team work and decision-making are crucial. Past scholarship has examined the relationship between the individual and the team, trying to assess if individual characteristics or the greater context of organizational life has greater implications for ethical decision-making.[12] Scholars have considered whether the problem or project itself could affect the ethical conduct of the teams and individuals involved.[13] The individual aspect of organizational work has been probed to assess how relationships and interactions may affect ethics.[14] While such studies have undoubtedly furthered our understanding of this murky area, they have failed to examine the social processes *themselves*, instead focusing on the outcomes and net effects of these considerations. Using a social network perspective to provide a more detailed understanding of the interactions and relations that are formed within these project teams around specific issues related to engineering design work, we identify and probe the effects of how team structures emerge around ethical and design-related issues, and enable engineering educators to understand, and later affect, the quality of ethical and design decisions made within teams.

Social Network Analysis

Social network analysis (SNA) is a type of analysis that enables researchers to examine the relationships among members of a given system or group.[15] The network analysis approach enables researchers to identify, visualize, and analyze the informal communicative patterns and networks that underlie the formal organizational structure.[16] In contrast to the "organizational chart" that might show how communication is *supposed* to flow within the organization, network analysis shows the *actual* communication and relationships that emerge within the organization or team.

In this approach, several key terms must be defined (for the definitions offered here, see Wasserman & Faust, 1994, ch. 1). *Actors* refer to the social entities, who are the individuals, corporate, or collective social units. *Relational ties* refer to the social ties that link actors to one another. A tie is what establishes a linkage between a pair of actors. Ties can represent a number of different relational linkages, such as behavioral intention, association or affiliation, formal relations, and cognitive ties, among many others. A *subgroup* is defined as any subset of actors, including the ties among them. This is in contrast to a dyadic or triadic relationship, which consists of two or three people, respectively.

Several elements of social network analysis are important for this study because they provide insight into the strength, linkages, and patterns of team networks. We examine external structural rules (or network-level measurements) of network density and structural rules (or those that give information about the participation of each specific actor in the network), and degree centrality. Different network structures have been found to affect employability, employee turnover, employee satisfaction, and creativity.[17, 18] Leadership network structure has also been associated with creativity in engineering design teams.[19] Krackhardt and Hanen (1993)[18] applied social network analysis to examine the trust network in a dysfunctional company, finding that the person appointed to lead the team was in practice not central to the trust network, meaning that others on the team did not trust him and would likely not rely on him as a leader. Social network approaches allow us to explain and predict practical issues that arise in team-based work, as well as being able to describe and illuminate the patterns of relations that actually emerge in organizational life. However, how such elements of team network structures affect team ethical decision making is not known. Indeed, Whitbred et al. (2011)[20] recommend that "future research should focus on establishing whether the structuration of social networks will vary depending on the nature of the organization and, if so, which structural rules would emerge as being most important in these other contexts" (p. 425) particularly for engineering design teams. Our study advances this call, attempting to investigate how different elements of design work produce different structures and how these structures may impact decision-making.

Relational concerns can have a major impact on how people work together, collaborate, and solve problems. Social network analysis offers an important perspective on the team process by showing how team members relate to one another *in practice*, rather than self-reports or prescribed structures for interaction. We use these analyses to uncover how information flows within the team, and which team members are influential in which contexts—potentially giving us insight into who the "moral or ethical authorities" on a team are and how their moral/ethical perspectives influence the team decision-making process. The social network measures help us to visualize the patterns of interaction that may affect the discussion and process of decision-making at a micro level, by showing a detailed account of the role each member plays communicatively in the team as well as the structure that emerges around those interactions.

Method

Participants & Procedure

This paper presents a portion of a larger study seeking to explore the communicative interactions and constitutions that underlie team processes in engineering design teams. In this paper, we present findings from one class comprised of five project teams situated within the EPICS Program at Purdue University. This program is a multi-disciplinary service-learning design course that emphasizes a human-centered design model. Student teams of undergraduates partner with local or global not-for-profit community organizations to define, design, build, test, deploy, and support engineering-centered projects that aim to significantly improve the organization's ability to serve the community. Students can participate multiple semesters; teams typically have a mix of returning and new students on the team. Students take on different team-level and project team-level formal roles for which they can volunteer or be appointed. Team-level roles include Project Manager, the overall leader of the team; Webmaster, the website content manager for the overall team; and Financial Officer, the budget and funds manager for the overall team. Project team level roles include Design Lead, the manager of the respective project team; Project Partner Liaison, the main point of contact between the project team and project partner, and Project Archivist, the manager of documentation for each semester of a project. The participants for this study varied in year, major, and length of time with the program and with each specific project (see Table 1). These demographic data were collected to help explain the roles and interactions that developed within this team. To protect confidentiality, pseudonyms were given to each participant. To assist in the analysis and visual representation of team relations, members of each project team were given the same initials and last name.

Table 1. Demographic and role breakdown of project teams.

Team Member Pseudonym	Formal Role	Year in school	Semesters with project	Semesters with program	Major
Aaron Abrams	Team member	Sophomore	1 semester	3 semesters	Mechanical Engr
Abbey Abrams	Design Lead, Team 1	Senior	1 semester	4 semesters	Mechanical Engr
Adele Abrams	Team member	Junior	1 semester	5 semesters	Mechanical Engr
Adi Abrams	Team Member	Sophomore	1 semester	3 semesters	Mechanical Engr
Anderson Abrams	Team member	Sophomore	1 semester	3 semesters	Electrical Engr
Annie Abrams	Team member	Junior	1 semester	3 semesters	Mechanical Engr
Danielle Dougherty	Project Manager	Senior	3 semesters	7 semesters	Mechanical Engr
Danny Dougherty	Design Lead, Team 2	Junior	3 semesters	4 semesters	Electrical Engr
Daren Dougherty	Team Member	Graduate Student	1 semester	1 semester	Industrial Engr
Dennis Dougherty	Webmaster	Senior	1 semester	3 semesters	Nuclear Engr
Diane Dougherty	Team member	Freshman	1 semester	1 semester	Biomedical Engr
Harrison Hanes	Team member	Sophomore	1 semester	2 semesters	Mechanical Engr
Heather Hanes	Design Lead, Team 3; Financial officer	Senior	2 semesters	2 semesters	Mechanical Engr
Henry Hanes	Team member	Sophomore	1 semester	2 semesters	Chemical Engr
Qayanat Quenton	Team member	Freshman	1 semester	1 semester	Mechanical Engr
Quincy Quenton	Design Lead, Team 4	Junior	1 semester	4 semesters	Electrical Engr
Quinn Quenton	Team member	Junior	1 semester	1 semester	Interdisciplinary Engr
Zach Zanes	Team member	Junior	1 semester	1 semester	Mechanical Engr
Zander Zanes	Team member	Sophomore	1 semester	1 semester	Electrical Engr
Ziyu Zanes	Team member	Senior	1 semester	1 semester	Mechanical Engr
Zoe Zanes	Design Lead, Team 5	Junior	2 semesters	5 semesters	Multidisciplinary Engr
Erinn Eubam	Teaching Assistant	Graduate Student	N/A	6 semesters	Biomedical Engr
Ertie Ebaum	Teaching Assistant	Graduate Student	N/A	1 semester	Electrical Engr
Dr. Kyle Kastan	Advisor	N/A	N/A	9 semesters	Mechanical & Biomedical Engr
Kristopher Kennington	Advisor	N/A	N/A	2 semesters	Biomedical Engr

Procedure

The researchers conducted a social network analysis with all 23 members. Because past literature suggests that leaders have a significant impact on team functioning, we included the two advisors and two teaching assistants because they represent an important resource for information and guidance to the project teams. These teams had lasted from one to three semesters with at least one returning member each. Because social network analysis requires a high response rate,[14] we were able to achieve a 100% response rate by offering cash incentives to participants. For this study, we explored the cognitive social relations that emerged on these teams surrounding technical, program, and ethical trust and advice. These relations were assessed using three questions: "I can rely on this person to have the technical competence needed to get the task done." "I can rely on this person to have the project knowledge needed to get the task done (non-technical)." "I would go to this person if I had serious ethical concerns about the project." We adapted these items from Chua, Ingram, & Morris (2008)[21] to assess cognition-based trust, which reflects the reliability and competence associated with trust, and affect-based trust, which involves empathy, rapport, and self-disclosure, for the specific constructs probed in this study. In keeping with Krackhardt and Hansen (1993)[18], this allowed us to assess the cognitive elements of the social interaction that takes place on these teams. We computed network density and degree centrality measures and generated a sociogram for each network to provide a visual representation of the relationships we analyzed.[15]

In addition to the social network analysis, we also conducted in-depth semi-structured interviews with 20 of the 23 members, including one advisor. These interviews were used to give limited qualitative insights into how team members perceived the relations in their project teams and to begin to probe why different people emerged as prominent in the network. In this study we present interviews with one project team of 5 people. Interviews averaged approximately 55 minutes, ranging from 48 minutes to one hour. Finally, we conducted non-participatory observations of every class meeting throughout the semester to provide context and insight into the interactions probed in the interviews.

Findings & Interpretation

For this study, we focused on two measures within the social network analysis: degree centrality and network density. Degree centrality indicates the network position of individual actors and reflects how central an actor is in the network. Network position refers to an actor's position within the network in relation to others. There are several measures of network positions, but for this study we focused on degree centrality. Degree centrality refers to the number of direct ties a node has to other nodes,[15,22] indicating how many people on the team evaluate that person as an expert or trust them enough to seek advice on a certain topic. We computed degree centrality scores for each individual on this overall team. We generated both in-degree measures, which indicate an actor's prominence by showing how many people included that actor in their network, and out-degree measures, which indicate an actor's influence or perceptions of others. We computed both measures because trust relations are directed, meaning that X trusting Y does not necessarily imply that Y trusts X. While in-degree measures allowed us to see how other members of the team perceive the participant, out-degree measures are limited by their self-report nature and allowed us to assess how the participant perceives him or herself in the context of the team.

We also computed network density for these three questions, which shows the proportion of actual relations to the total number of possible relations.[15] A highly dense network indicate that the actors are all communicating with one another frequently, generating more opportunities for information, opinions, and values to be shared.[15] For the purposes of this study, higher density also indicates more interactions within the team around the relevant concept, suggesting the relative importance of that topic to the team as a whole.

Our findings revealed that the networks which emerged around technical, programmatic, and ethical advice differed in potentially significant ways. We discuss the density and degree centrality measures that we examined for each of these three questions. First, density varied by question for this team. Density for the technical and program trust networks were identical (0.402), indicating that almost half of the team interacted with each other surrounding these respective concepts. Network density for the ethical network was much lower (0.277), indicating that only around 30% of team members would seek each other out for ethical concerns.

In examining degree centrality, we found differences and similarities between the three networks. All three networks were somewhat centralized (with proportions of 0.6233, 0.5365, and 0.6753, respectively), indicating the presence of one or a few actors with much greater centrality than the rest. Comparisons of degree centrality between the three networks also yielded insight. Across the entire team, responses for the ethical network were significantly decreased from the technical and program advice networks. The ethical network was the most highly centralized, indicating that the highest scores varied significantly in value. These relations are visually represented in the sociograms for each of these three questions, presented in figures 1-3, in which node sizes reflect an actor's degree centrality.

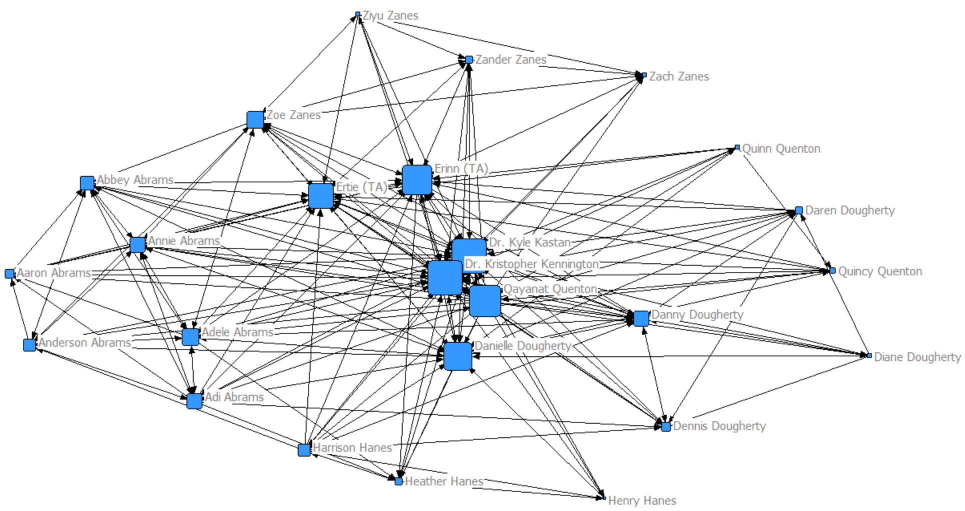

Figure 1: Sociogram of the informal relationships that emerged around technical competence.

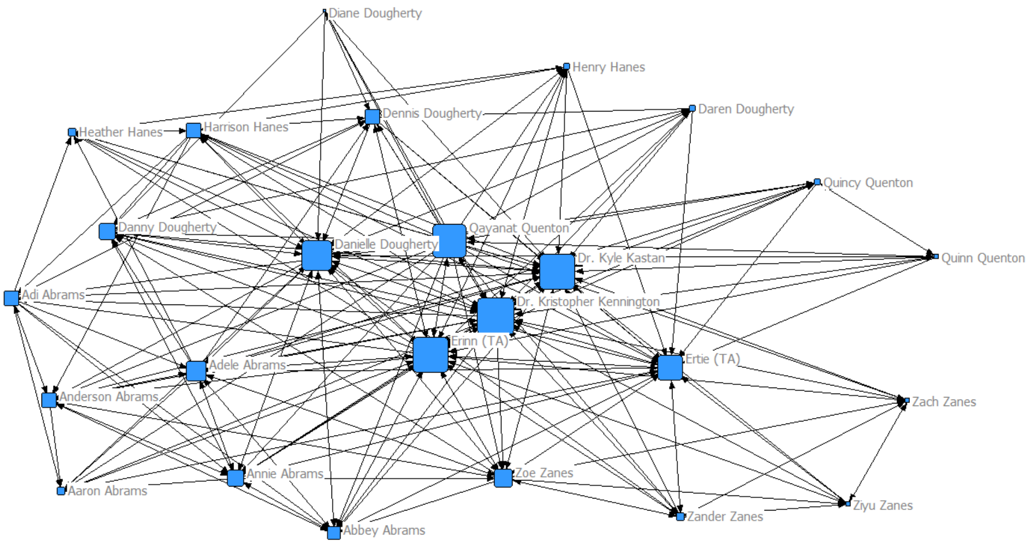

Figure 2: Sociogram of the informal relationships that emerged around program knowledge.

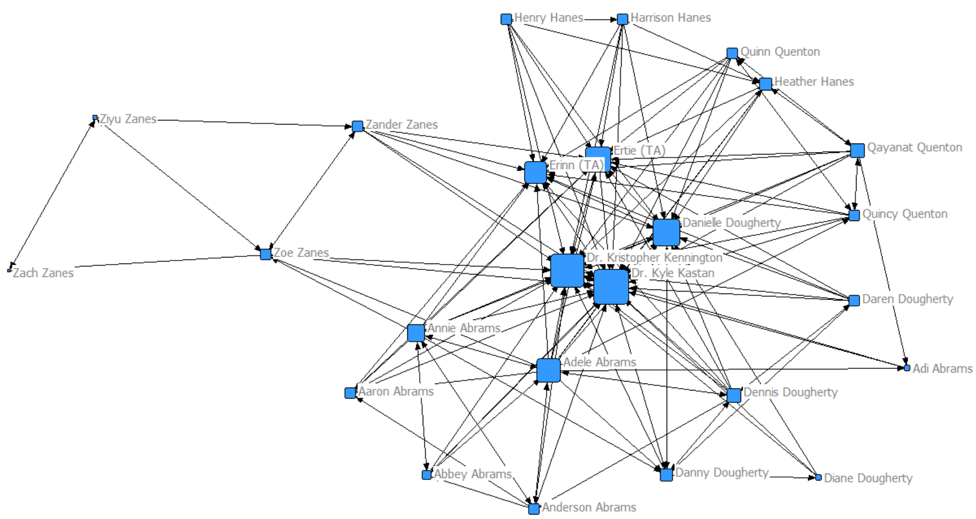

Figure 3: Sociogram of the informal relationships that emerged around ethical advice.

The sociograms provide a visual illustration of the differences in these three networks. While the density for the first two figures was the same, the more centralized distribution of the technical network is evident in how tightly clustered the center nodes are in figure 1. The significant lack of ties (lower density) and highly centralized distribution of figure 3 is also clear in these depictions. We discuss some interpretations and significance of these results in the following section, where we put these findings into conversation with the qualitative analysis of team member interviews. In keeping with the mixed approach presented in this paper, these findings are discussed in conjunction with insights from the results of the social network analysis.

Premises for Role Emergence

These findings provide insight into how roles emerge and change within a team, as well as the influence different roles in the informal social networks within a team. The difference in the structures of the technical, program, and ethical networks implies that these three things are viewed differently in this team, and shows that certain team members affect these three issues differently within the team social process. In examining the individual performance of team members across these networks, some interesting patterns emerged for each network.

Technical Network

Analysis of the technical network provided insights into the technical dimension of engineering design work and how interaction structures developed around technical expertise. At the network level, this network had moderately high density, indicating that team members interact with each other around this topic reasonably frequently. The moderately high proportion of centralization indicates that a few actors earned much higher scores than the rest. This suggests that a few team members emerged as more of the technical experts in the team.

In examining individual positions, across all three networks, the two advisors earned the highest scores for centrality, indicating that across all three constructs, team members felt they could go to the advisors or perceived them as experts in those respective areas. In the technical network, the two TAs followed, first Erinn and then Ertie, followed closely by the Project Manager, Danielle. The next tier of high scores was mostly among Design Leads. There were a number of high or moderately high scores in this network, indicating that many individuals perceived a number of their team mates as technically competent to some extent. While the network analysis shows that team members in formal positions of authority rated higher in technical expertise, the explanations offered by participants in the interviews suggests some of the possible reasons why those positions are regarded in this way.

First, technical competence seemed to be linked to levels of experience. The individuals with the five highest centrality scores in this network were graduate students, professional engineers, or a graduating senior who had been in the program all four years of school. Dennis explained that he picked "basically people who I thought knew the technology the most. And I guess I see the TAs as people who are grad—I mean, just grad students who are able to provide any input." Similarly, Dennis linked technical expertise with ability to provide technical guidance: "[I picked people] if I asked this person for help with something technical… If I had a problem with something technical, could I go to them?"

These constructions of technical competence were reflected in the demographic data for the project team members. The Design Lead for teams 2, 3, 4, and 5 were all either the only returning member or the member who had been with this particular project the longest. On several project teams, a team member with a lower class ranking could serve as the Design Lead because of his or her longevity with the project. These demographic distinctions suggest that technical expertise is not simply based on seniority, class ranking, or major, but rather it is highly dependent on the project context itself. This sentiment was borne out in Danielle's description of her selections for technical competence, from the perspective of the overall team Project Manager:

These are all—I mean, I've seen their skills, they've been on the team. They're usually the driving force behind the project as well. You know, I've seen that as kind of a pattern on the team, is Design Leads have a clear vision of what needs to get done, and kind of can take the project in their own hands and lead that project on their own, without too much issues or dependency on the advisors or myself or the TAs.

Thus, technical competence also seemed linked to the possession of certain skills relevant to the project. Danielle described her skill-based perception: "Technical skills, for me, really depend on the project. So that's coding in Arduino, building a circuit board, doing CAD modeling, any hands-on skill that kind of builds and progresses the project is what I would define as technical skills." While she identifies specific engineering skills as credentials for technical expertise, she also links those skills to the advancement of the specific project. Along the same vein, Diane, the freshman new member on Team 2, said that possession of general technical skills was not sufficient for the highly electrical project of which she was a part:

So I'm good with anything in the machine shop or whatever. Like, I can do that. So if they'll be like, "Go cut in this half," and I can do that, it's fine. But a lot of the knowledge stuff, like all the complicated physics or like— I just haven't taken all these classes that they've taken. And all the like, "Go wire this," and "Go . . ." Like, I . . . (laugh) I'll electrocute myself.

Program Network

While the technical network was a primary focus for engineering design team work, the importance of expertise related to the program in which these projects were situated was also examined. At the network level, the program network had the same density as the technical network, indicating that this is a topic around which people on this team interact and consider. However, this network had a lower proportion of centralization, indicating that the higher scores were more proportionally distributed among the team members and it was not quite as dependent on the expertise of only a few. While the two advisors were still ranked highest and the TA Erinn's score was the third highest, Danielle's centrality measured fourth, above the other TA, Ertie. This indicates that team members perceived Danielle as more of an expert in programmatic competence than Ertie.

One possible explanation for this difference is the longevity in the program itself. While Ertie was a graduate student and rated higher in the technical network, Danielle had been with this program all four of her years during her undergraduate education. Danielle described her own view of the distinction between Erinn and Ernie: "Erinn actually used to be on [this team], and she's been through [this program], where I know Ernie I think is brand-new to the program." She went on to explain how this longevity with the program impacted her assessment of the two in terms of program competence:

It's not his ability to be a TA. Like, he's been great, really helpful, but I know . . . at least in comparing the two, I would have stronger confidence in Erinn than Ernie. Like I said, there's a learning curve for everyone, and I have no doubt that—you know, he's been doing a good job, but I've also seen Erinn kind of leading that front.

Dennis also articulated this sentiment, tying it to familiarity with the processes and procedures particular to the program:

> *Basically just experienced with [the program], and I thought of, um . . . I definitely thought of people who had roles in [the class], like as in like Project Partner [Liaison], like something like that, so they just are familiar with like the [program's] way of doing things. Because I know Danny and just other ambassadors for [the program], they have the proper [program] competence. I think project competence falls under that scope as well.*

These assessments also suggest the reason for the high scores of most team members in this network as well. Returning members were assessed as having greater program competence, regardless of their class standing, major, or other factors. Referring back to Figure 2, the members on the most extreme edges of the network were all first-semester participants in this program. Diane, Quinn, Ziyu, and Zach were all participating for their first time on any project in this program, and they all rated lower in this network despite other differences such as class level (they include Freshmen through Seniors) or major. Diane articulated this sentiment concisely:

> *Okay. Basically I put everyone except myself and Daren because …I know this is his first time working with the project, and I feel like him and myself just because we don't know really the background of the project. But everybody else I think knows. Like obviously Dr. Kastan and Kristopher know … what [this program] is and the history of the project. I think they've been involved since the beginning. Danny and Danielle and Dennis I'm pretty sure have all been there since the beginning.*

Diane places herself and Daren on the same level of non-expertise for this network, despite Daren's status as a graduate student and expert in his area. For his part, Daren also articulated this sentiment: "It's not really an engineering kind of thing; it's more just a [program] . . . you know, if you're in [the program], you need to learn how to do this." These findings all suggest that program competence is distinct from technical competence and is assessed differently by team members. Clearly, the members of this team see program and technical competence as different kinds of resources within design work.

Ethical Network

The ethical network differed the most from the previous two in several ways. As a network-level measurement, the low density for this network indicates that individuals were not communicating with one another as frequently around this topic as in the previous networks. The low values for network density and across the board in degree centrality in the ethical network suggest that team members are more selective about ethics, or perhaps are more uncomfortable identifying it in their work teams. The high centralization for this network indicates that in addition to the low general level of interactions around ethics, those interactions that do take place are highly dependent on a small number of actors.

This network also showed differences in individual positions. First, after the two advisors, Erinn and Danielle tied for the second-highest scores, with Ertie coming in with the third highest score. This indicates that team members perceived Danielle as more central to the ethical advice network, meaning that they would go to her for ethical advice above Ertie, the other TA. While formal roles and traditional sources of authority hold much weight in team dynamics, this divergence suggests that there is something about Danielle that appeals more significantly to their sense of ethical guidance than Ertie. One possible explanation could be similar to the program network--Danielle's longer history with the project may have in some way impacted her team members' assessment of her ethical expertise. This aligns with the high scores received by the advisors and Erinn as well. However, after these five, the scores for the other team members were all very low and did not demonstrate the same pattern of high scores for longer membership. Indeed, referring back to Figure 3, Zoe Zanes, who after the advisors and Danielle was tied for the longest membership with the program at 5 semesters, is located on the periphery of the network. Adele Abrams, who was identical to Zoe in class standing and longevity with the project, is located more centrally. While new members such as Diane, Anderson, and Ziyu are still on the periphery of the network, returning members like Abbey, Aaron, and Adi are also out there. These findings suggest that something more is going into team members' assessments of ethical expertise in this team that may be independent of some of the qualifications discussed in the technical and program network.

The participants articulated this intangible quality to their ethical assessments in the interviews. In contrast to some of the tangible descriptions participants offered of physically witnessing demonstrations of technical skills or program competence, they spoke more tentatively about why they selected individuals for their ethical network, appealing more to intangible cues, "gut feelings," and inferences. Dennis justified his selections by saying, "I think I just selected people who I thought, just based on my own intuition, had a pretty good moral compass about them." Indeed, based on the qualitative data it seems likely that perceptions of ethical expertise are associated strongly with peripheral cues, such as length of time working together, feelings of liking or similarity, or general assessment of interpersonal cues like being talkative or "nice." Participants struggled to articulate or justify these assessments, often relying on statements such as "there was just something about him." While this issue is not yet fully understood, the low values for degree centrality and network density in the ethical network suggest that team members are more selective about ethics, or perhaps are more uncomfortable identifying it in their work teams.

Conclusion

This paper offers a new method for examining engineering design teams that may be particularly useful to engineering education programs, as well as offering insights from the application of this method into the social processes underlying engineering design team work. The social network analysis and qualitative results of this study indicate that technical competence, program knowledge, and ethics are interrelated yet distinct components of design work in an engineering education program. Our findings suggest that these three elements of design work in an engineering education program are seen very differently by members of these teams, and the interactions surrounding them emerge and develop in distinct ways. Our findings suggest that elements of team processes such as relational links, assessment of others' character, and talk about team issues are all important to understanding overall team functioning. We also found that students use different decision premises for assessing technical, program, and ethical competence. While an individual may be seen as an expert in one area, they may be seen very differently in another area, which in turn affects the emergence of the networks surrounding these three constructs and the individuals who may have more influence in these areas. This study provided an initial step into studying how team members navigate the complex social processes underlying design work.

Additionally, this study suggests some of the complex relationship between ethics and design. The inconsistency of centrality measures related to team member demographics and the inability of participants to articulate their decision premises for ethical expertise reveals a tension between some of the more frequent assessments found in the other networks and the emergence of the ethical network. Future research is needed to further untangle the complexities of the emergence of the ethical network. However, this approach used in this study provides much insight into how different aspects of design and team work function differently on this team. We also provided insight into how ethics is perceived and handled *in practice* on a team engaged in practical engineering design work with specific community partners, building on previous studies that probed ethics in experimental or hypothetical scenarios.

Finally, these findings also indicate that the participants were more comfortable with and able to make assessments about team members' technical and program competence than ethics. Our findings support and further past scholarship in this area, which indicates that ethics is often unnoticed or dramatized in an engineering design context[2] and that students struggle to identify the role and prevalence of ethics in their teams. Indeed, these findings suggest that not only is ethics elusive as it relates to the project and the design process itself, but also as it relates to individuals engaged in this work together.

Our findings offer important insights to engineering educators by promoting better understanding of how ethics is manifest in project-based program contexts, as well as how ethics seems to be identified, attributed, and managed differently from technical and program knowledge. A major focus of engineering education is on teaching and practice of the technical and program skills needed to engage in design work, but this approach begins to offer additional insights into the need for ethics to be taught as a fundamental part of design, and promoted as an important aspect of design work. Further study is needed to investigate specific suggestions for how to successfully integrate ethics into design-based program contexts similarly to the level of technical and programmatic knowledge expected of students.

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