A Communicative Approach to Exploring The Development of Ethical Team Processes Over Time

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Abstract— This study contributes to our understanding of the social and communication processes that affect students' engagement in design work. We examine ethical considerations in a multidisciplinary design projects as students work through the challenges of team collaboration and struggle to integrate the ethical and technical aspects of engineering work. We use a mixed methods approach to investigate how design teams come to understand and create meanings for ethics in their projects, as well as the social mechanisms by which these students incorporate the diverse kinds of expertise of their team members throughout the course of their design work. In this work-in-progress paper, we will present preliminary results of an analyses of three data points across two semesters. This approach to ethics in engineering design can illuminate the social relations that influence design work and enable or hinder students to effectively recognize and incorporate ethics in their everyday work.

Keywords—Multidisciplinary teams; engineering ethics; social network analysis; teamwork

I. Introduction

Scholarship in science and technology studies (STS) has shown that engineering design is a context in which ethical issues arise on a day-to-day basis or in what is called "everyday context".[1] We examine "everyday ethics" in a multidisciplinary context which offers further challenges, as teams try to integrate the diverse knowledge, opinions, and skills of team members.[2,3] Few studies have considered the social processes by which different values are incorporated into team-based design work. Fewer still have attended to the communicative construction of team member contributions and the network structures that reflexively shape the team relations that facilitate such work, and how they change over time. We use a mixed methods approach to investigate how design teams come to understand and create meanings for ethics in their projects, as well as the social mechanisms by which these students incorporate the diverse kinds of expertise of their team members throughout the course of their design work. We combine an evolutionary social network approach[4,5] with a discourse approach[6] to explore the reflexive relationship between team network structures and the communicative relations that emerge in design teams, especially as related to technical and ethical issues.

II. Literature

A. Social and technical values in engineering design

Engineering design, education, and practice involve a myriad of considerations, not the least of which is integration of technical considerations with social, cultural, and ethical aspects.[7,8] Organizational globalization, virtual collaboration, cultural diversity, and the highly social nature of design work itself[7,9] are just a few factors that necessitate engineers' abilities to work cooperatively and learn to incorporate diverse perspectives, specializations, and values into the design process. The highly social nature of design work itself [7,9] requires novice engineering students to learn about, recognize, and practice the social sides of engineering, an effort advanced by many researchers and practitioners in recent years.[3,10,11,12,13] Yet much of the extant literature has failed to incorporate insights from organizational and team research outside of engineering education and related disciplines.[10]

This study focuses on the emergence of technical versus ethical concerns in design project teams. While technical coordination has long been a primary consideration for both scholars and practitioners,[8] there has been less definitive progress on integrating ethics into pedagogy and practice.[14,15] We adopt the "everyday ethics" view from science and technology studies (STS)[1,15] that views ethics as inherently interwoven throughout the design process and manifest in the micro-decisions and practices of design work. As a first step toward developing more effective integration of technical and ethical considerations in student design work, this study explores how these two design considerations emerge as relational components of team-based design work. We particularly considered the communicative environment in which the social processes of design are accomplished as multidisciplinary teams try to coordinate and collaborate.

B. Communicative approach to ethics in design teams

We use a social network approach combined with discursive analysis to probe this reflexive relationship. Social network analysis (SNA) is an approach that enables researchers to examine the relationships among members of a given system or group. The network analysis approach enables researchers to visualize and analyze the informal communication patterns that underlie the formal organizational structure.[4] By combining this approach with discourse analysis (DA) in a longitudinal study, we probe how network structures and discourse of team members were mutually constituted and change over time as they are influenced by organizational and team values and practices in which they are embedded.

This work in progress paper focuses on preliminary SNA results of a longitudinal study as a portion of this larger study. We offer limited insights from the discourse analysis to

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elucidate and illustrate some of these findings, but reserve the full DA for a future paper. Our findings answer our two guiding research questions: (RQ1) How do network densities change over time across technical and ethical relations? (RQ2): How does network centralization change over time across technical and ethical relations?

III. Methods

As part of a larger study, we collected social network surveys and interviews from students in multidisciplinary design projects at a major Midwestern university. In this program, students engage in real-world design projects and deliver solutions to community partners. The program employs a human-centered approach to design. All students participate in a lecture on ethics that focuses everyday and professional ethics as it relates to a case study as well as their own projects. Students are asked to reflect on ethics periodically throughout the semester. Project teams of this study consisted of 3 to 9 students, and were situated across two classes (Class A and Class B). Classes shared a common theme, advisor, and teaching assistants, and project teams worked both independently and with other teams in each class.

We gathered social network surveys and in-depth interviews (*M*=52:47 minutes) from 94 participants, with no less than 90% participation for each class. We conducted the surveys at three "observation" points throughout two semesters. Observation 1 was conducted in the last weeks of the first semester; Observation 2 was conducted in the middle of the second semester; and Observation 3 was conducted in the last weeks of the second semester. We also conducted extensive interviews of weekly lab meetings, generating field notes and over 170 hours of observation each semester.

A. Social network analysis

We used two items to probe technical and ethical relations: "I can rely on this person to have the technical competence needed to get the task done," and "I would go to this person if I had serious ethical concerns about the project." These items were adapted from Chua, Ingram, and Morris (2008)[16] to reflect the engineering design project context. Students were presented with a roster of their class members and asked to identify each member to whom they felt these statements applied by marking a 1 to indicate the presence of that relationship, or a 0 to indicate its absence. These responses were developed into matrices and analyzed using SIENA[17] network analysis software, which allows researchers to examine network evolution over time. We probed participants' understandings of and meanings associated with both technical competence and ethical concerns in the interviews, which will be discussed in a later paper.

We considered two measurements for social network analysis: network density, and network centralization. *Network density* reflects the ratio of ties that exist in a given network to the total ties possible in that network.[4] Density scores range from 0 to 1, with 1 indicating complete connection among all members. Density measures suggest how interconnected a group of people may be, and in this study, the degree to which team members identified one another as ethical or technical resources. *Network centralization* reflects the variability in degree centrality of all the actors in the network.[4] Degree centrality measures the network position of each individual actor by reflecting how central he or she is; actors whose team members all include them in a given network will have higher degree centrality. Higher network centralization scores indicate the presence of a small number of actors with much higher degree centrality scores than the rest, meaning that a few actors in the team are the most prominent and influential in a given network. Centralization also ranges from 0 to 1, with 1 indicating one actor with significantly higher degree centrality.

IV. Results

SNA analysis revealed patterns that suggest ways students organized around technical versus ethical considerations.

A. Density

The first research question asked how network densities changed over time for technical and ethical relations. Network density scores varied in similar patterns across the two classes. To compare these densities, we applied Snijders and Borgatti's (1999)[18] bootstrap-assisted paired samples t-test to technical and ethical networks for each class at each observation. Density scores and results are shown in Table 1.

TABLE I. COMPARING DENSITIES

Class A: Observation 1			
	Class A technical network	***Class A ethical network***	***Difference***
Density	0.4017	0.2267	0.1750
Bootstrap SE (5000 samples)	0.0575	0.0496	0.0760
t-statistic			2.3037*
Significance			<0.05
Class A: Observation 2			
	Class A technical network	***Class A ethical network***	***Difference***
Density	0.3140	0.2143	0.0998
Bootstrap SE (5000 samples)	0.0472	0.0396	0.0616
t-statistic			1.6186*
Significance			<0.05
Class A: Observation 3			
	Class A technical network	***Class A ethical network***	***Difference***
Density	0.3547	0.6736	-0.3190
Bootstrap SE (5000 samples)	0.0487	0.0538	0.0725
t-statistic			-4.3970*
Significance			<0.05
Class B: Observation 1			
	Class B technical network	***Class B ethical network***	***Difference***
Density	0.3567	0.3246	0.0322

Bootstrap SE (5000 samples)	0.0515	0.0558	0.0759
t-statistic			0.4239
Significance			>0.05
Class B: Observation 2			
	Class B technical network	***Class B ethical network***	***Difference***
Density	0.3072	0.1993	0.1078
Bootstrap SE (5000 samples)	0.0576	0.0505	0.0766
t-statistic			1.4076*
Significance			>0.05
Class B: Observation 3			
	Class B technical network	***Class B ethical network***	***Difference***
Density	0.6144	0.5033	0.1111
Bootstrap SE (5000 samples)	0.0650	0.0704	0.0958
t-statistic			1.1597*
Significance			<0.05

The technical and ethical network densities were statistically significantly different in all cases except one, observation 1 for Class B. Thus, the densities for these networks are different enough that it is reasonable to conclude these differences do not occur by random chance. The differences in technical and ethical networks for these classes suggests that relations between students may manifest distinctly around these two considerations.

a) Comparison across time: Across observations, both technical and ethical network densities exhibited the same trend. They dropped slightly between observations 1 and 2, and then rose significantly during observation 3. To interpret this finding, one important consideration is that team members join and leave the group between semesters. This could account for the difference between the first and second observations, in which new members were added to the classes. However, another consideration is the timing of these observations. As indicated earlier, observation 1 and 3 were both conducted in the last weeks of the semester, while observation 2 was conducted in the middle of the second semester of project work. Thus, the lowest densities manifested earlier in the semester, when students had worked together for a shorter period of time and were less confident in assessing one another's abilities. In their interviews, they largely accounted for the changes in their network responses by claiming not to have known or worked with a person enough in the first survey of the second semester to include them in their networks. However, once technical and ethical attributions were made in the second survey, students' descriptions of their team mates suggested stable views of their identities, and students even invoked experiences during the first half of the semesters as examples to justify their second survey responses.

These results suggest that the duration of project work may impact students' perceptions about the role and identification of technical and ethical relations on their teams. As time goes on, students feel more comfortable in their assessments of their team members' character, and more confident in their attributions of technical and ethical relations. This finding may offer some insight into the project-based pedagogical aproach to engineering design education. As a result of the educational context, membership in these project teams shifts every semester, with some members returning but some new members also joining every several months. While the project itself may remain the same for multiple semesters, teams go through a period of assessing one another and establishing norms for how they will interact. This insight has been widely acknowledged in group communication literature and other research into group norm development.[2]

b) Comparison across class: In all but one case, the technical network densities were larger than the ethical networks. This indicates that students identified more of their team mates as technical relations when asked whom they would rely on to have the technical knowledge needed to get a task done. In contrast, fewer team members were included in students' responses when asked to whom they would go if they had an ethical concern about the project. The higher densities for technical than ethical networks suggest that students are either more comfortable assessing technical relations than ethical, or perhaps that they saw more team mates as technically reliable than ethically. In preliminary considerations of this finding, we note the greater emphasis of tehcnical discussions in classes than ethical. That is, while ethics is taught through lectures, surveys, and class discussions, by virtue of the nature of design work technical considerations were discussed more frequently by students on a daily basis as they worked through design issues and troubleshooting their projects. This finding aligns with literature from group communication research, which suggests that information to which all members of a group have access is more likely to be discussed and invoked in group work.[19] While students have access to information about ethics, interview analysis and observations suggest that they were less readily able to identify and consider ethical considerations relevant to their specific projects. While this finding merits further investigation, our initial results suggest that more intentional, frequent integration of ethical considetations may improve students' ability to identify and value it.

B. Centralization

The second research question asked how network centralization changed over time for technical and ethical relations. The centralization scores for each respective semester are shown in Table 2 below. Centralization scores were highly variable. Generally, centralization scores were lower in Class B than Class A, suggesting that overall, centrality scores for actors in Class B were more evenly distributed rather than having just a few actors with high degree centrality scores.

TABLE II. CENTRALIZATION SCORES

Technical Networks		
Class A	**In-degree**	**Out-degree**
Observation 1	0.62	0.62
Observation 2	0.49	0.67
Observation 3	0.52	0.67
Ethical Networks		
Class A	**In-degree**	**Out-degree**
Observation 1	0.68	0.41
Observation 2	0.48	0.78
Observation 3	0.23	0.30
Technical Networks		
Class B	**In-degree**	**Out-degree**
Observation 1	0.32	0.54
Observation 2	0.42	0.42
Observation 3	0.28	0.41
Ethical Networks		
Class B	**In-degree**	**Out-degree**
Observation 1	0.41	0.47
Observation 2	0.29	0.54
Observation 3	0.34	0.53

While these results require further investigation for full understanding, they may give us insight into the way technical and ethical considerations are addressed within these teams. For example, in observation 3 for Class A, the ethical network had a higher density and much lower centralization. In observation 1 for this same class, the density is very low but the network is much more centralized. Thus, not only are students identifying ethical relations less in the latter example, but they are highly dependent on just one or a few actors for ethical relations while technical relations are more evenly distributed. Such analyses could provide insight into who is serving as ethical resources for a given team; what attributes or characteristics may account for their emergence as central in this context; and the influence of these social processes on overall design work in these teams.

V. CONCLUSION

This work in progress study contributes to our understanding of the social and communication processes that affect students' engagement in design work. Through a communicative approach involving social network analysis, we provide insight into the team social processes that facilitate, hinder, or otherwise affect the ability of teams to fully recognize and integrate ethical considerations with technical design concerns. This study allows us to better understand of the relationships and resources to facilitate ethical reasoning within diverse design teams, with the potential to help students improve their work and interactions, and engineering educators develop our ability to design effective curricula that aids teams in valuing and incorporating the many competing values that characterize design work.

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