Infrastructure Sinkholes: The Pretense of Operating Gender Neutral Organizations Erodes Engineering Education

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Abstract

This paper draws from the framework of Feminist Scholar Joan Acker's Gendered Organizations (1990; 2012) to examine the shifting landscape of engineering education and related networks. Analysis of interviews with over 30 engineering education researchers reveals organizational dynamics and gendered relations present in both day-to-day work environments and engineering education reform efforts. National conversations with professional societies, industry representatives, and federal agencies seek to articulate public values to which engineering education should respond, and seek to drive change through funding mechanisms, bully pulpits, accreditation, and governance of the profession itself. Examining these directives through a feminist lens reveals possible limitations of what is currently imagined as an ideal for which the field strives, and whose concerns are addressed and presented. Grounding in feminist theory helps to work a basis that organizations can be and are cultural - a notion many organizational scholars note as an integral force for understanding change (Schein, 1990). It provides the researchers and the research itself the ability to be reflexive while paying critical attention with regard to gender and other oppressive intersections as they arise in analysis. As organizational dynamics unfold layers of written and unwritten regulations eroding the engineering education profession, which scaffold gender neutral engineering practices, power is enacted and must not only be acknowledged but addressed. These power relations within organizations influence all aspects of change potential in engineering education and are not limited to change related to diversity, equity, or inclusion. Through attending to these aspects of organizations, we can focus on understanding how to shift power dynamics to enact change at various levels.

Introduction

The current infrastructure of the academy is based on small, separate parts of a whole - disciplinary colleges, departments and/or centers. Often times disciplines are segregated according to specializations and attributes to the discipline. This institutionalization of individualism within the academy can have the ability to facilitate worker isolation (Bennett, 1998) and discourage interdisciplinarity. This separation (through literal and abstract barriers) can isolate individuals from easily creating collaborations within their discipline and has the ability to create a divide between subdisciplines (Terviö, 2011).

Though Engineering Education has had the ability to cross disciplinary barriers and begin to shed light on the necessary changes needed in the education of future engineering leaders (e.g. Baillie, et al. 2011; Adams, et a; 2011), interesting paradoxes within the field regarding the potential isolation of engineering education researchers is surfacing. When not directly connected to engineering education departments and established centers, newcomers, individuals with diverse professional backgrounds, and even women tend to remain on the periphery a status we referred to here as "*lone wolves*". *Lone Wolves* are researchers that perform education research within the

field of engineering, but face systemic and geographic barriers to the larger and smaller engineering education networks.

Engineering education as a discipline functions as a network with various types of connections, links and *ties* (to both individuals and entities). Networks can be a powerful tool for change-making (or the lack thereof) in higher education. Connecting isolated individuals through network *ties* to desired and thus sustainable networks has the potential to yield cohesion and solidarity (Lieberman, and McLaughlin, 1992).

An integral force for change-making and reform can be understood through network analysis. As organizational network connections are found, layers of written and unwritten policies and regulations have the potential to erode the expansion of the engineering education profession. The distancing of engineering education and interdisciplinarity reinforces gender neutral engineering practices and therefore power dynamics that must not only be acknowledged but addressed. These power relations within organizations influence all aspects of change potential in engineering education and are not limited to change related to diversity, equity, or inclusion. Through attending to these aspects of organizations, we can focus on understanding how to shift power dynamics to enact change at various levels. This paper explores the importance of researcher network *ties* in engineering education and the potential for member isolation when their background and work is nonconforming or non-traditional for the network.

Network Analysis

Through Network Analysis (NA) theorization, researchers work to understand behaviors as cumulative reactions to structures where norms are viewed as effects of *structures*. NA is based on the examination of a social system where the structural constraints promote opportunities for individuals where their actions merely respond to the system they are embedded within. In this approach, inequalities can result from social contracts, patterns, and access to resources or information. Through applying the understanding that structures influence acceptance and rejections of network membership, it is implied that nonconformity to network parameters would equate to direct and indirect partial or whole exclusion. Additionally, network *ties* and strength related to gender proportions within the network structure and ideals, as well as the rate of mobility.

Researchers utilize social network *ties* between *nodes* to understand the structural properties of networks. *Nodes* are individuals (e.g. researchers, institutional agents), groups (associations), or entities (universities). Network *ties* are said to provide significant benefits and/or hindrances due to their ability to connect *nodes* to resources and information. *Ties* are the connections between *nodes* and vary in their strength. Essentially, what we are talking about here is the interactions and collaborations between researcher's (one particular level of *nodes*) across groups or entities (other levels of *nodes*). Strength of *ties* (which can range from weak to strong) creates networks of interdependency based on connectedness. Particular *nodes*, *ties*, and their strengths are the main structures of analysis that matter in the NA method. Through the NA frameworks researchers avoid normative explanations on social behaviors and aim to understand and study regularities of community behavior (Wellman, 1983); social processes are not seen as summative of the individual but of the whole interconnectedness of the network's social contracts.

Through viewing the university as an organization, we apply the framework of Gendered Organizations by Joan Acker (1990; 1992; 2006) to help understand the potential embeddedness of gendered practices reinforcing exclusion. Since so much of engineering research comes out of the university setting, and universities are here delineated as organizations, then it can be said that engineering networks are inherently gendered as well (an investigation the authors of this paper are currently perusing to clarify in forthcoming papers). Network barriers can be produced through the structure of a network and tend to be embedded in its functionality, processes, and practices. The gendering of an organization privileging some while disadvantaging others through reinforced patterns distinguishing between male and female or masculine and feminine, where gender distinctions are the basis of a network's foundation (Acker, 1990). Understanding that an organization, like universities, are gendered through their normative functionally is not enough to enact change. It is not simply a matter of saying gendered practices are acknowledged and now we will be gender-neutral. The illusion of gender-neutrality is just that, an illusion, simply reenacting practices and processes through distinctions that masculinity equates to superiority. Networks that are formulated through and are bolstered by gendered organizations, are replicate the same distinguishing practices and procedures. For example, this can be seen in engineering through the valuing of technical skills, a masculine attribute, and the devaluing of social skills, a feminine attribute (Faulkner, 2000 & 2007; Cech, 2013).

Networks Ties, Gender, & Tokenism

Distinguishing weak *ties* from strong *ties*, researchers link the dependency of these *ties* to internal promotion of individuals through network resources and information (Granovetter, 1983). Loose acquaintance relationships have the potential to act as common threads that can become bridges to weak *ties* and therefore resources and information for *nodes* (individuals or departments) to connect with. DiMaggio & Garip (2012) suggest that those with few weak *ties* were less effective in resource and information gathering and less occupationally mobile. Therefore, it is argued that groups are bound internally by strong *ties* and benefit from the maintenance of weaker *ties* to other groups) due to the function weak *ties* have in bridging *nodes* (Stanton-Salazar, 1997). Bridge-making functions as a thread to new *ties.* For example, my research mentor (a *node)* introduces me to their long-time collaborator (a separate *node* that has a strong *tie* to my research mentor) - now I have a weak *tie* to a new researcher (a new *node).*Though many weak *ties* may seem to have no realistic function, it is argued that the ability to have several functioning weaker *ties* lends toward the benefits of bridge-making and network building; a benefit not seen for many isolated *nodes* like the *lone wolf* researcher.

Although it is beneficial to maintain several weak *ties* along with strong *ties* within an individual's network, Stanton-Salazar (1997) note the ability to maintain several weaker *ties* is one that accompanies privilege because of the time-consuming nature of fostering several weaker *ties*.

Too much time spent on strengthening weak *ties* can be difficult, particularly those whom are commonly tokenized, like women in engineering or those with interdisciplinary degree backgrounds. Cultivating several functioning weak *ties* assumes unwritten network requirements that are problematic due to their gender-neutral structure, an informal unwritten practice of networks. With men usually in the highest positions of power (seen also in engineering fields today), network structures are related to gender composition of the network and leadership within the network; therefore, making women tokenized members (Kanter, 1977). In a network, members tend to select individuals that reflect themselves for entry to a network and leadership within the

network, which would indirectly make women (or non-gender conforming individuals) tokenized. Tokenization consequentially delegitimizes that individual (or group) which creates structural sinkholes that can collapse opportunities for career expansion (Schoen, Rost & Seidl, 2018).

Homophily of Networks

In a case study of primary education institutions examining the adoption and characteristics of lower status individual's ability to 'break into' high SES skills, persistence, and retention in institutional structures, DiMaggio and Garip (2012) utilize NA to relate the homophily associated with inequality in schools because of their organizational networks. For example, skill background or gender and network sustainability, mobility, and resource attainment is hindered by a networks homophily (newcomers reflecting tenured members). Through NA, homophily of networks, organizations, or institutional agents refers to the commonality of associating and creating *ties* with similar others. Through this thought process more contemporary applications of network analysis points towards systemic mechanisms of network homophily creating inequalities. Institutional Agents serve as a specific type of *node* within a network and are individuals with power and privilege in a particular network.

Reinforced behaviors enacted through social networks help to reinforce inequalities where the reproduction of actions is closely related to social contracts (the socially acceptable way of acting, working, collaborating, etc.). Individual choice then is pressured by network peers to conform to their normative processes and practices. In academia, challenges of interdisciplinarity can be particularly strenuous. Engineering as a discipline can be viewed as a large network, but when you examine engineering more closely, you understand that the various subdisciplines are strong networks with *ties* (connections) to the overarching network of engineering. Sometimes crossing disciplinary lines, even from one subdiscipline of engineering to another can be particularly difficult – especially as institutional factors (like Tenure & Promotion) are taken into consideration. Needless to say, this can be particularly challenging for those integrating educational research and methods. Breaking into new, more affluent networks, without the mediation of institutional agents, is seemingly impractical. This suggests that network effects and advantages are related. In the case of engineering education, institutional agents that have the ability to navigate both traditional engineering and engineering education research are particularly helpful *ties*. The main argument in this association with NA is that network processes and practices effect resources and information.

Traditionally engineering is a male-dominated discipline, so the insurgence of female-identified individuals into this education-heavy domain presents challenges across the entire network; especially since networks tend to be homophilous in nature. Stanton-Salazar (1997) notes that there are persistent and consistent barriers in social networks that privilege some and disadvantage others. Through relationships with institutional agents and various other levels of *nodes* (such as departments) disadvantaged individuals have the potential to gain the skills required to strengthen their position in the network and thus open other institutional supports and opportunities; but seldom without integration from the institutional agents and bridge-making assistance from strong *ties*. Acknowledging the potential for social structures and networks to inhibit and effect actors (i.e. institutional agents) illuminates' ways to investigate and understand systemic mechanisms where dominant groups (males) organize themselves to capitalize their *ties* and draw resources.

Understanding this particular connection can aid in understanding how to integrate those isolated from the network or with weak or disjointed *ties*, like women in engineering.

Often times we discuss the disadvantages of students navigating the university system, their discipline, and their path towards graduation. On the outskirts of the academy are researchers navigating networks and *ties* to maintain resources, information, power, and relevance. Due to the interdisciplinary nature of engineering education, researchers straddle various appointments to maintain knowledgeable and active pursuits of contributions. However, since the normative degree background in engineering education tends to be a traditional engineering degree, this particular homophily in the field can at time be a hinderance to the advancement and acceptance of those who seek to enter and flourish in engineering education with differing degree backgrounds. This undefined and multi-faceted aspect of engineering education can put at risk those with diverse professional backgrounds or isolated researchers (such as researchers with a Science, Technology & Society [STS] degree conducting engineering education research).

Network Analysis & Institutional Agents

Institutional Agents serve as a specific type of *node* within NA. Institutional agents are individuals who transmit resources and information and therefore opportunity; they can also be institutionally assigned *roles* (such as an instructor). For example, in the sense that it may not matter who the instructor is covering an introductory course during any given academic year, what matters is that *someone* fulfills the duties of that role and that role is essential to the functionality of the overall network. Viewing institutional agents through this perspective provides for a more sociological way of understanding the impact of institutional agents. Yet if you think about the ratio of males occupying institutional agent positions, and the likelihood of those institutional agents retaining positions of power in networks, then it can be assumed that masculine traits will be more valued within that network. These institutional agents assimilate the same gendered processes and practices valued at the organization which houses the functionality of their network (in the case of engineering the organization being a university).

Access to institutional agents is vital and sometimes unobtainable for some individuals due to rejection based on professional status, professional background, or regurgitated practices that are gendered. This can lead to conflictual behaviors between individuals and institutional agents leading to tension within network connections, potentially breaking strong or several weak *ties*. Time constraints of institutional agents is problematic, as the need for *ties* to them is high, but their ability to maintain the resources for such a high demand is low. In other words, researchers can only handle so many meaningful mentorships or tasks due to time constraints. Because of constraints, institutional agents tend to develop strong *ties* to only a few. Network members that are disadvantaged due to lower status in the network usually lack the skills to understand how the system works, and thus ways to manipulate the system and obtain the maximum benefits from it.

Methods

Network Analysis Applied. Network analysis is particularly interesting in attempting to understand the current evolving landscape of engineering education as it continues to develop. Network Analysis is a tangible technique that can be used to inform research on understanding network functionality. Here we are utilizing NA to understand the functionality of network practices and

procedures within engineering education. Institutional agents, such as engineering education researchers, profoundly impact the shape of the discipline, the acceptance of newcomers, and the integration of diverse bodies and educational backgrounds in the fields network. However, autonomy of these institutional agents is influenced by organizations that empower the network connections (*ties).* That is to say that the organizational gendering of practices is carried forward through institutional agents that assume positions of power in the engineering education network. This query is seeking to understand how influential institutional agents state they are impacted by the infrastructure of their organization. Additionally, we are working to map links between connectedness of the larger engineering education network and reasons for isolation from the network.

Interviews. In order to accomplish this analysis, the authors conducted semi-structured interviews with engineering education researchers (n=32) that associate as members of the engineering education network. Interviews were molded after Saul Alinsky's (1989) relational meetings and conducted via Skype. Implementation of Saul Alinsky's (1989) relational meetings for the conducted interviews is forthcoming (Quiles-Ramos, et al 2019). Individuals were recruited through email listservs for engineering education, informed consent was obtained in writing before interviews, and interviews were audio recorded with permission from the participant. Interviews were based on a protocol, but allowed for participants to navigate the conversation so responses were authentic and not prompted. Participants included individuals with researcher positions, corporate/industry positions, teaching & learning positions, and university leadership from a range of institution types and locales. Particular institutions were not solicited for participation as this would not provide for a wide enough range in network connectedness. Interviews were transcribed and thematically coded in qualitative analysis software, with codes derived from the network analysis framework. As this is a work in progress, analysis is still being conducted and new emergent themes continue to be found. Here we present some preliminary findings.

Coding. Network Analysis (NA) utilizes individuals, groups, or entities as *nodes* in a network to examine *ties* (relationships, links, or connections). We classified individual researchers, universities, and large organizations (e.g. ASEE) as *nodes*. A major focus of NA revolves around *structural relationships* through analyzing patterns among *ties* to understand how social structures constrain social behavior and social change (Wellman, 1983). In order to measure *ties,* we linked nodes depending on their mention of particular individuals, universities, and/or other organizations like ASEE.

Particular *nodes*, *ties*, and their strengths are the main structures of analysis that matter in the NA method. In order to measure the strength of *ties,* reciprocal mentions of particular nodes are being taken into consideration, as well as mentorships, university affiliations, positions, and educational backgrounds. Through utilizing the NA frameworks, researchers avoid normative explanations on social behaviors and aim to understand and study regularities of community behavior (Wellman, 1983); social processes are not seen as summative of the individual but of the whole interconnectedness of the network's social contracts in this method.

Feminist Theory. Feminist Theory provides the researchers and the research itself the ability to be reflexive while paying critical attention to gender and other oppressive intersections as they arise in analysis. Grounding our analysis in feminist theory and network analysis provided a perspective about academia as an organization and the way this organization can dispense power through assumed institutional interactions that effect network connections and advancement. Through incorporating feminist theory, the authors acknowledge their *feminist objectivity* (Harding, 2004; Harraway, 1988). Though traditionally used for quantitative research, the authors are working to recognize what Harding (2004) and Harraway (1988) note to be the acceptance that all knowledge is situated. Hesse-Biber, Leavey, and Taiser (2004) summarize that *feminist objectivity* is "knowledge and truth that is partial, situated, subjective, power imbued, and relational (p. 301)". By combining *feminist objectivity* with Joan Acker's (1990) framework of gendered organizations, the authors are working to be reflexive of their understandings of organizations and their role in networks, application of network analysis frameworks, and overall analysis.

Results and Discussion

Several themes rose out of the preliminary findings. As the authors worked to carefully lay the groundwork for a detailed outline of Network Analysis applied to engineering education networks, in this paper the authors will discuss the finding that related institutional infrastructure aiding and fostering homophilous network barriers, and information exchange between seasoned and newer network members.

The Gender of Engineering Education Infrastructure

Institutional infrastructure aids homophilous networks. Creating and maintaining stronger *ties* to institutional agents is even more critical for marginalized individuals (Stanton-Salazar, 1997) where disadvantage extends to those outside of the traditional network functionality. Basically, individuals associated with a particular network tend to bond to similar others. Although this may seem potentially obvious or simple, this is an important finding for a developing discipline like engineering education.

Homophily particularly existed for member's who had nonconforming educational backgrounds. That is to say, more than half of the participants with nonconforming educational backgrounds noted resistance within engineering education networks. Nonconforming educational backgrounds were degrees obtained outside of engineering. Additionally, of all the women interviewed, 58% stated disadvantages to working in engineering education, such as problematic mobility practices (T&P), position assignment, and the lack of appreciation for educational research in their universities. An overwhelming 80% of participants noted that their educational research was not considered prestigious enough, and of those participants, more than half (60%) were not positioned in a free-standing engineering education department. Participants that reflected nonappreciation of their educational research outside of a free-standing engineering education department, were noted as *Lone Wolves.* The importance of researcher membership into the engineering education and the formation of network *ties* cannot be overstated to avoid isolation.

With the mentioned homophily results it was found that individuals with only a few weak ties tended to be *Lone Wolves.* The problematic nature of homophily in networks found is supported by Granovetter's (1983) mention that nodes are linked by the dependency of their *ties.* Mentorship

for newcomers to engineering education researchers was noted as lacking by a majority of the participants (72%), suggesting that those with few weak *ties* were less effective in resource and information gathering as noted by (DiMaggio & Garip, 2012).

Particular assumptions are maintained through the implications embedded in the infrastructure of the organization for which we work. For example, the university system was founded on the teachings, modeling, and structure of historical male-dominance. Today we argue that most workplace procedures are gender-neutral, adhering to all, however these institutions 'assume a universal worker – embodied in masculinity and male' (Acker, 1990), and further we could add white, able-bodied, and hetereosexual. The same male-dominance maintains in the discipline of engineering, "where engineers value social hierarchy on a continuum giving most prestige to scientific abstraction, least to feminine qualities (Hacker, 1981)". The presence of this tension, where such a dualism exists and is maintained, embeds itself into the discipline and is reinforced through infrastructural practices. It is important to acknowledge that these phenomena exist despite engineering education having near gender parity in terms of participation compared to traditional departments, engineering education has a lot of women - but that doesn't necessarily translate to their being strong *ties*.

Several participants, not in engineering education departments, indicated difficulty with finding ways to have their engineering educational research acknowledged and designated as part of their tenure and promotion review. Many practitioners in 'traditional engineering' (mechanical, electrical, etc.) engaging in either scholarship of teaching and learning or in engineering education research noted the difficulty with having their educational contributions acknowledged due to their "lack of rigor" (Riley, 2017) or scientific abstraction. The reoccurring notion of educational contributions to engineering as lesser than abstraction was profound and gravely disturbing. Nearly 20 years after Faulkner's(2000) contribution of the technical/social dualism operationalized in engineering workplaces, we find 'dichotomous styles of thought in engineering, where hierarchies and gender are often evident - symbolically and organizationally', still being maintained despite our best efforts.

Additionally, concerning was that most of the researchers noting difficulty in their educational contributions being acknowledge were female or did not have a background in a 'traditional engineering' discipline, or were not in engineering education departments. As engineering education departments begin to flourish and departments begin to spread, the devaluing of individuals without 'traditional engineering' training is disturbing. Professionals with advanced degrees in Science, Technology, & Society (STS), STEM Education, etc. have the ability to contribute meaningful insights towards the advancement of engineering, and exclusionary practices through formal and informal means hinders the fields advancement. Individuals not in traditional engineering education departments reported equal as difficulty as did females. If "the technical defines the core of engineering expertise and identity, specifically excluding `the social (Faulkner, 2000)" advancement of engineering education as a field will maintain stagnant progress.

Network Bridges & Ties

The exchange of informal information between seasoned researchers and newcomers was found to be an interesting area to focus on. The interconnectedness of national, regional, and local

conferences or workshops provided fruitful resources for information dissemination and gathering. Bridge building was found to be critical during pre-organized and structured events, where resources tend to be shared through informal conversations. Since seasoned researchers attend these events in anticipation of high quantity interaction, many newcomers utilize these times to informally build bridges to the seasoned researcher's network, hoping the introduction will lead to weak *ties* that can be fostered. In several of the interviews, up-and-coming researchers stated that conferences and workshops were essential towards developing their strongest *ties*, such as graduate mentor, department head, or co-workers.

Information on navigating reward structures in a technical field while doing education research was a common but integral finding that repeatedly came up. The need to understand how to properly negotiate tenure and promotion given the interdisciplinarity of engineering education and the culture and expectations of one's broader institutional environment is a task that is made easier when connected to successes that have experience. Additionally, many researchers in the sample reported utilizing conferences as meeting grounds for ongoing projects or launchpads for new projects.

Although large conferences and workshops are an important asset of resource sharing to engineering education, there are barriers. Some participants reported the feeling of isolation from the larger network of engineering education due to the distance of their university from the larger hubs of the discipline and due to lack of funding to attend engineering education conferences. Distance from the bigger engineering education departments seemed to hinder bridge building unless larger events were attended. These isolated researchers reported not having the financial resources to fund travel, lodging, and conference fees. Some of the isolated researcher reported attending local conferences, however many of the more seasoned researchers usually only attended national events. Indirectly this disengages researchers from forming meaningful *ties*. Although bridges may have the potential to be built, isolation from the larger network leaves little to no room for fostering even a weak *tie*.

Funding and distance to large events were a main barrier for some researchers. Researchers who noted they were unable to attend events even though they desired to do so were at a disadvantage. Several of the researchers that regarded their location of work as distant or their funding as limited also identified themselves as working for a smaller institution, noted their positions to be non-tenure track, and tended to be female. These researchers were identified as isolated from the network with more detached *ties*. Essentially these researchers found themselves to be what we are calling them, "*Lone Wolves*."

Summary

Interesting paradoxes within the field regarding the potential isolation of engineering education researchers is surfacing. When not directly connected to engineering education departments and established centers, newcomers, individuals with diverse professional backgrounds, and women seeking advanced positions in the network tend to remain on the periphery a status we of "*lone wolves*".

Overall, conferences and workshops were reported to be critical for these groups of researchers in bridge-building and in forming weak *ties* that lead to strong *ties* within the engineering education

community. Additionally, the recurrence of large organized events provided prime ways to maintain connectedness with the larger network fostering both weak and strong *ties*.

Disadvantage was seen for individuals with alternative backgrounds, newcomers, and for females practicing in the network. Incorporating educational research into a traditionally technical profession presents challenges that make it difficult for individuals without specific advanced training or education in engineering. Engineering, being a male dominated profession, presents additional barriers for females working to integrate into the field and thus the overall network. If the structural functionality maintains their traditional upbringing with gender-neutral foundations, the result is a network of researchers maintaining the same norms of favoring particular individuals, namely males.

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