The Identification of Alters That Influence Asian Women's Career Intentions in Civil Engineering

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The supply of talents in the U.S. civil engineering is a persistent issue. The civil engineering workforce is mostly composed of aging White men, hence candidates of all races and gender are needed. Between 2010 and 2020, civil engineering students dropped by 3000. Because not all engineering graduates work in the same field, full-time student enrollment is lower. While recruiting all students is crucial, less is known about underrepresented minority students like Asian female students. Asian women can exhibit transformational leadership through collaboration, compassion, and empathy. Working civil engineers appreciate these leadership-coupled talents, which can boost team and organizational performance. Yet, Asian women are understudied and partially represented in civil engineering research on women of color. They should be studied in light of gender, race, and environment because they are overrepresented by race and underrepresented by gender. Therefore, the goal of this paper is to raise the voice of Asian women in civil engineering by identifying people they indicate as influential for their formation of career intention. To learn more about the experiences of Asian civil engineering students, this paper identified the influential people or alters that Asian women perceive as influential in their decision to become civil engineers. A qualitative study was used to examine 10 Asian women's career aspirations. This study employed social capital theory to identify alters that participants receive support for their career choice in civil engineering. By using the social capital theory as a theoretical lens, the social network that Asian women access while pursuing their career interest could be captured. As a data collection instruments, this study used a name generator and sociogram. In data analysis, this work used the participants' description of their alters shared in these two instruments to code and characterize the alters. This study found professional, academic, and non-civil engineering influences on Asian women's career intentions. The study recommends educators and recruiters strategize recruitment activities for Asian women in civil engineering by providing opportunities for, and broadening access to, social network.

Introduction

One of the issues that this work aims to solve is supply shortage of talents in the civil engineering industry. The American Society of Civil Engineers' (ASCE) Vision for Civil Engineering in 2025 asks for future research to contribute significantly to the increase of a skilled workforce [1]. According to a previous estimate, about 315,000 civil engineering positions must be added by 2030 to meet the need for future civil engineering projects [1]. Although the work of civil engineers is increasingly recognized by American society, where they have helped improve the sustainability of infrastructure and the quality of the environment [1], the supply of civil engineers is constrained by the steadily decreasing number of students enrolled in civil engineering programs. Statistics reveal that while full-time engineering enrollments nearly doubled between 2010 and 2020, the number of undergraduate students studying civil engineering declined by 3,145 [2], [3]. Although people with other degrees who enter the civil engineering workforce partially satisfy the demand for competent workers [4], more research is needed to analyze and strengthen support systems for civil engineering students to stay in the field.

Amongst the workforce, Asian women have talents to contribute to the success of civil engineering projects. According to Burke and Collins [5], women leaders often use transformational leadership, which is considered the most successful type of leadership [6]. Likewise, Asian women in leadership positions demonstrate and adopt the value of leadership-coupled skills that motivate others to work together, support one another, and genuinely care in order to achieve a common goal [7]. Civil engineering professionals noted that these leadership-coupled competencies are greatly desired [8]. Although these competencies are observed in Asian women, little is known about the ways through which Asian women in civil engineering programs form a decision to pursue a job in the field.

Social connections promote Asian women’s career interests. Social connections extend beyond the professional domain to include relationships with family members, who frequently have a significant impact on the career decisions of Asian women students. Past research has demonstrated that the familial influence of students, coupled with their college experiences, influences their career interests and decisions [9]–[12], especially those in Asian cultural context [13]. In fact, students are more likely to pursue employment in an industry in which a family member has or is working [14] because family connections increase their chances of discovering their interests in jobs and work environments. Interestingly, students are considerably influenced not so much by the family members themselves, but by their exposure to those family members' professional roles and responsibilities [14]. In contrast, Asian parents' perceptions of engineering careers as inappropriate for women discourage their daughters from pursuing engineering careers [13].

Also, social ties with friends and peers, particularly those of the same gender and at comparable developmental phases of careers or education, can also help women pursue their desired careers. An earlier study found that female friendships act as "social vaccines" that reduce women's sense of threat in a male-dominated group, reduce their sense of being neglected, and increase their participation [15]. This is the result of relationships that enable women to candidly discuss their experiences with overcoming obstacles, acquire confidence, and overcome obstacles to advance their careers. By recognizing these social connections as a source

of support and enhancing access to a professional network, Asian women enrolled in programs for civil engineering can redirect their career interests despite facing obstacles.

Literature review

When their identities are separated, Asian women are both overrepresented and underrepresented in civil engineering. According to Pew Research Center, Asians are expected to be the largest immigrant demographic in the United States by the middle of the twenty-first century [16]. Asian American women make about 2.9% of the US population [17]. In civil engineering Asians account for 13.6% of the civil engineering workforce, with Whites accounting for 81.9% [18, p. 11]. Indeed, Asians constitute the second largest group and are overrepresented in civil engineering; however, Asian women are underrepresented. The Multiple Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD), a database that has been used to examine the career paths engineering students take, showed that about 2% of civil engineering enrollments were Asian women in 2013, whereas approximately 8% were Asian men [19]. Moreover, a recent report by the U. S. Bureau of Labor Statistics indicated that the number of Asian women professionals were four times fewer than the number of Asian men in the construction industry in 2022 [20]. Although the two industries are slightly different, these statistics imply that Asian women's experiences cannot be understood simply as inheriting Asian's privileges.

Asian women face a number of challenges when completing their engineering programs. There are few female leaders in civil engineering [21] and even fewer Asian women leaders. Since there are so few Asian women leaders in civil engineering, it is difficult for prospective civil engineering students and working professionals to find the role models they need to succeed in a traditionally male-dominated field. Likewise, underrepresented minority students struggle because they don't have instant access to resources that can help them be better prepared for their chosen fields [22]. Due to these barriers, it may be inferred that Asian students, although often outperforming their non-Asian counterparts, may exhibit lower levels of academic self-efficacy [23], [24].

Asian women, who are more likely to encounter racial and gender stereotypes in the workplace, have distinct experiences due to the complex nature of identity creation at the intersection of race and culture. The model minority stereotype, for instance, paints Asians as the ones who succeed in spite of prejudice and disadvantage [25]. This prejudice is harmful to Asian students because it expects them to conform to a certain mold: they must be (1) very clever, especially in math and science; (2) diligent; (3) pursuing academic status; (4) seeking economic accomplishment; and (5) uncomplaining [18]. Racial bias dismantles Asian students' confidence and performance because they worry about not performing to expectations, fitting in with the culture, and seeming foolish. As a result, some Asian students may decide to drop out of engineering programs [26], [27].

Even though Asian people are not statistically underrepresented in engineering, there is a number of evidence that their experiences in engineering are more like those of people of color than of White people. This means that they are not as privileged as White people and is especially true for Asian women [28], [29]. Mozahem and colleagues [22] found that, women of color are more likely to feel undervalued and their decision to study in engineering is more likely

disparaged by others. These obstacles consequently influence female engineering students' career path. Asian women in particular are expected to pursue particular professions due to outmoded perceptions of conventional gender roles by their family members and the cultural society they are a part of [30]. Furthermore, when pursuing engineering jobs, Asian women frequently express worries about their gender due to the following reasons: 1) feeling under the pressure to demonstrate proficiency beyond that expected of male colleagues, 2) believing the need to match masculine or feminine qualities with gender norms, and 3) coping with preconceptions against working mothers [31]. Women in civil engineering are disproportionately impacted by sexism, obsolete and anti-feminist gender stereotypes, and gender inequity, which renders them "outcasts, unwelcome, and mistreated." [32, p. 240].

Asian women enrolled in civil engineering programs quickly become aware of these realities after being exposed to the workplace through fieldwork, industry guest lectures, internships, and co-ops. These students learn about the current barrier in the workplace (such as a lack of role models) via interactions with working professionals, which eventually prevents them from entering the field [21], [33]. Barriers experienced by women in civil engineering include integration into a masculine culture, stressful and competitive work environments [34] that make family and career difficult to balance [35], professional disillusionment [36], lack of networks for career opportunities [34], lack of promotion opportunities compared to men [37], and feelings of isolation and intimidation [38], [39].

To assist Asian women in overcoming a variety of obstacles, it is essential to understand how Asian women develop and sustain their career interests while in college. Prior research has shown that engineering students, including those pursuing degrees in civil engineering, are able to gain confidence in math and science skills, manage financial concerns, and find a source of motivation [40]. This finding highlights the impact of early career interests on the likelihood of completing a degree. Women were more likely to be engaged when the source of their motivation and the outcome of their performance were linked to positive societal impacts such as water supply, environmental degradation, poverty, and disease [41]. Thus, outcomes related to addressing societal issues can empower women to actively pursue civil engineering careers [42].

Social ties, which are defined as relationships or interactions in which two individuals exchange information, resources, and support, are one way in which women influence such outcomes [43], [44]. Also, a term "alter" was used to indicate the influential people for participants (ego). Alter was first used in 1985 General Social Survey [45] which was used to inquire about people's social ties (e.g., alter 1 and alter 2). In the same vein, this study uses alter to indicate influential people that Asian woman identify as important for pursuing a civil engineering career.

Contrary to the emphasis on the influences from alters, Navarro-Astor and colleagues [46] found in their systematic literature review on the persistence of women in the construction industry that women's social network is a relatively unexplored area. Therefore, it is important to identify the alters that Asian women access and receive support in navigating career paths in civil engineering. To achieve this goal, this study used a qualitative study to uncover influential people that Asian women identify as helpful in becoming civil engineers. The following research question is going to be addressed in this study: Who are the alters that Asian women develop social ties with to help them form an intention to enter the civil engineering workforce?

Methods

Theoretical framing

Social capital theory is a construct that allows the researchers to understand a formation of social networks and experiences of support. Social capitals are resources, trust, support, and empathy that individuals share within the social networks and relationships [47], [48]. Although these networks are critical for students' accessibility and awareness of career opportunities, they are not equally shared by all populations [49], [50].

Asian women in civil engineering are not the exceptions. Given the negative gendered climate and culture in the program as well as in the industry, there are multiple challenges, such as the model minority stereotypes and gender stereotypes, that discourage Asian women from finding and developing social capitals. Especially for students interning at a company, they are likely to experience or realize these challenges that were not obvious in academia. By using the social capital theory as a theoretical framework, the social network and forms of support that Asian women shape in pursuing their career interest can be captured.

Participant recruitment

In order to attract and recruit participants, this research created a boundary of case. The U.S. Census Bureau [51] defines Asian as "a person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam." The selection criteria were who (1) self-identifies as an Asian woman, (2) is enrolled as an undergraduate in a civil engineering program, (3) is in their third year or higher, (4) has lived in the U.S. at least 65% of their life, and (5) identifies ethnic orientation from a country in the East Asian Cultural Sphere (i.e., China, Japan, Korea, Taiwan, Vietnam). These criteria were used to capture common experiences that the Asian women may share in accessing their social network for career choice.

This study started by sending a recruitment email to the heads of professional student organizations at the top 15 Asian-serving institutions that grant engineering bachelor's degrees [3] as well as 2 other institutions that the first researcher attended in the past. These professional student organizations included the Society of Asian Scientists and Engineers (SASE), American Society of Civil Engineers (ASCE), Society of Women Engineers (SWE), and Engineers without Borders (EWB). The email outlined the study's goals and requested information from participants, including their gender, ethnicity, planned graduation year, and names of any mentors or supporters (e.g., gender, title, and role). This research recruited ten people in total as a result of the participant recruitment activity. The Table 1 below displays the general background of the participants.

Table 1. Participants recruited in the study

Name	Academic year	Major	Region	Ethnic group
Autumn	fourth or above	Construction Management	Midwestern	Chinese

Kat	third year	Civil Engineering	Western	Taiwanese
Marielle	third year	Civil Engineering	Midwestern	Chinese
Ana	fourth or above	Civil Engineering	Western	Taiwanese
Jenny	fourth or above	Civil Engineering	Western	Vietnamese
Katie	third year	Construction Management	Southern	Chinese
Taylor	third year	Civil Engineering	Western	Chinese
Kayla	third year	Civil Engineering	Western	Chinese
Kelsey	fourth or above	Civil Engineering	Western	Japanese
Alexis	third year	Civil Engineering	Midwestern	Chinese

Name generator survey

The name generator survey was used to develop a preliminary understanding of the individuals that Asian female students identify as crucial in influencing their interest in and/or confidence in civil engineering as a profession. The name generator survey may include questions like, "What is their name?" "What best describes their gender?" "What kind of work do they do?" and "What best describes your relationship with them?" The participants were requested to list at least five individuals who, in their opinion, had a significant influence on their decision to pursue a profession in civil engineering.

Sociogram

Participants were instructed to draw a sociogram that represented their alters for the researcher. Network diagrams with nodes that symbolize individuals and ties that reflect their connections are referred to as sociograms [52]. The researcher gave participants the following instructions as a prompt: "Draw a social network that contains individuals you think have assisted you in deciding your future job in civil engineering." Each participant was asked to sketch a network of people in a position that was relative to them (i.e., the "You" at the center of the sociogram), where proximity would reflect the degree of support or influence those people had in cultivating the participants' interests in civil engineering careers and helping them through difficult times. Figure 1 is an example of sociogram by drawn by a participant, Katie. The names of alters are removed for their confidentiality and participants selected their pseudonym to be used in this study.

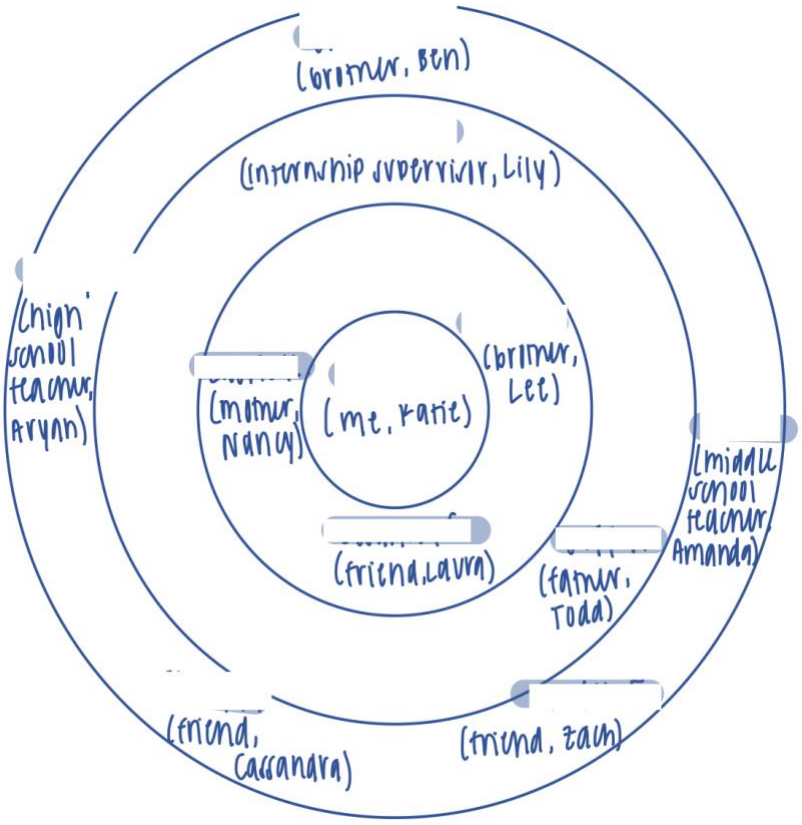

Figure 1. An example of a sociogram drawn by Katie

Data analysis

The participant-drawn sociograms were analyzed to match the influential alters indicated in the name generator. Once a preliminary understanding was gained, a qualitative inductive coding approach was utilized to identify common alters. In this phase, alters' similar demographic information was grouped together to capture salient characteristics such as job title, race/ethnicity, gender, and relationship. While analyzing the data, it was observed that all participants indicated that family members helped support their career interests. To capture this emergent observation, kin and fictive kin relationships were used as codes. Then, categories were developed to thematically capture unique relationships that each group of alters fostered with participants.

Findings

This study found three salient alters: professional, academic, and non-civil engineering alters. Table 2 provides a description of each alter's definition. Every participant mentioned having at least one fictive kin or kin professional alter. Many participants indicated that they were significantly influenced by a family member who worked in the field of civil engineering (n=13).

Table 2. Categories of alters and the definitions

Category of alter	Definition	Codes	# of codes	Subcodes
Professional	Working professionals in civil engineering who are either fictive or fictive kin. These people provide industry-specific knowledge and exposure to the work environment.	Fictive kin professional	5	Internship supervisor
				Internship mentor
				Fellow civil engineer
		Kin professional	13	Uncle
				Brother
Academic	Those encountered in an academic setting who provided advice and suggestions regarding coursework, future career paths, personal development, and guidance on helping them to achieve academic success.	Faculty	12	A faculty member in a first-year engineering class
				A faculty member in a student organization
				A faculty member in a civil engineering course
				Faculty advisor
		Peer	18	
				Peer in CE
				Peer in a student organization
Non-civil engineering	Those who provide general supports that are not discipline-specific but offers encouragement and guidance	Kin	11	Dad
				Mom
		Peer	5	Roommate
		High school educator	7	High school teacher
				High school coach

Professional Alter

Professional alters included both the fictive kin and kin professionals who were working in the field of civil engineering. In this study, kin professional alters included participants' uncles and brothers. Participants also indicated that their brothers were influential for their career intention in civil engineering. Participants whose family members, such as brothers and uncles, worked in the civil engineering industry, indicated that they helped support their career interests in civil engineering.

Furthermore, fictive kin professionals helped participants develop interests in civil engineering. Fictive kin professionals were working professionals that participants met while

interning at a civil engineering company, such as supervisors or mentors. Interestingly, amongst the 14 fictive kin professional alters, nine of them were women, and four of these women were women of color (i.e., Hispanic and Asian). Every participant in this study indicated that their interactions with professional alters supported them to navigate career interests.

Academic alter

Participants identified academic alters were influential for their career intention in civil engineering. Academic alters include faculty members and peers. Participants' engagement with faculty members varied from taking first-year engineering classes to getting involved in the faculty-led student organization. Of the 30 academic alters, 12 were faculty members.

Furthermore, peers were influential for Asian women in reinforcing their interests in and passion for civil engineering careers. Peers in student organizations served as leaders of the group (i.e., president, coach, division chair), and participants' relationship with these alters helped to foster interests in civil engineering careers. Participants also perceived their peers in civil engineering courses as influential. These peers were mostly Asian women: amongst the 11 peers in civil engineering, seven of them were Asian women.

Non-civil engineering alter

Non-civil engineering alters included kin professionals, high school educators, and peers. Eight out of 10 participants indicated that non-civil engineering alters were influential for developing a career intent. Non-civil engineering alters include mothers, fathers, roommates, and high school educators. Interestingly, participants who identified their father as supportive located them in the outermost circle, indicating they were relatively less influential than others in the sociogram. On the other hand, people who identified their mother as influential positioned them in the innermost circle. These results may imply that mothers play a very influential role for Asian women in civil engineering.

Moreover, participants indicated that high school educators influenced their career interests in civil engineering. High school educators provided pre-college experiences, but their relationships with these alters were not as long-lasting as those of their peers. These responses my imply that high school educators offered participants opportunities to explore engineering-related careers and helped them develop an interest in pursuing a major in civil engineering in college.

Furthermore, peers outside of civil engineering include three roommates and one working professional. Participants met these roommates during their first-year when they took a first-year introduction to engineering class. These peers were identified as non-civil engineering alters who were not necessarily within the field of civil engineering but helped participants develop interests in civil engineering.

Discussion and Implication

This work adds to a growing body of intersectional research in civil engineering with a focus on the social relationships that Asian women access to form a career interest in the field. Although there are a number of studies investigating students' career development, there are few

studies that investigate civil engineering students as a sole population [53]–[56]. Therefore, the findings of this study shed light on exploring the experiences of individuals who share intersecting identities (i.e., Asian women in civil engineering) while fostering motivations for career development.

Professional alters in the workplace who share the same gender and race/ethnic background were influential for Asian women to develop an intention to pursue a civil engineering career. This study found that Asian women appreciated their relationship with professional alters who shared similar demographic backgrounds. Research indicates that female engineering students report a lack of support during internships [57], particularly from their supervisors [58], [59]. In contrast to male interns, female students report difficulty receiving adequate feedback and answers to their inquiries [58]. In the study conducted by Anderson and colleagues [59], female students are more likely to report that their mentors as not always attentive to queries. Such a disparity in experience and support may dissuade female students from pursuing an engineering profession after graduation, given the crucial opportunity internships provide for students to learn and practice key skills for their future employment [57].

The findings of this study also suggest that the role of female supervisors in the civil engineering workplace is critical for Asian women to share their concerns about difficulties and aspire to be like them. This study found that female supervisors were particularly helpful for developing career interests. Previous research suggests that in order to be inspired by a role model, one must be able to identify one's future self with that role model [33], [60]. The successful other serves as a “proxy” to follow in pursuing one's own goals [60]. Similarly, more recent work proposes that people can evaluate their ability to perform a novel task by comparing themselves to similar individuals who have already attempted the task [61], [62]. A successful Asian woman may serve as a valuable proxy for assessing one's own potential for success in the future because Asian women may encounter gender-related impediments to high-status positions in civil engineering jobs. Therefore, the gender of a leader at a company may be seen as a proxy that affects performance outcomes for Asian women [21], [63], [64].

This study also suggests educators of civil engineering programs (i.e., academic alter) must develop supportive cultures and networks that allow women to comfortably pinpoint, refine, strengthen, and achieve their career objectives. This study found that about half of academic alters were faculty members, suggesting that they play crucial role in shaping career choice [65]. Academic alters can take a role of encouraging Asian women to participate in services and activities, in order to capitalize on the interests and intentions of Asian women in civil engineering fields. Most students meet with an academic advisor once or twice a year to plan their studies or courses for the following semester. This meeting is significant because it allows students to discuss whether they would like to continue in their current major or pursue something new. In order to encourage their advisees to continue in the field of civil engineering, advisors can engage them in a dialogue in which they are encouraged to review their goals.

Also, campus organizations, particularly those established for service-based projects or historically underrepresented groups, may provide another avenue for students to develop and bolster interests in a civil engineering career [66]. Habitat for Humanity, Engineers with Borders, and Bridges to Prosperity are a few examples of organizations that were identified as influential

in this study. Aspirations may be strengthened by involvement in these organizations by creating a sense of community and belonging with peers who share the same goals [15].

Additionally, this study informs recruiters of how to best collaborate with academic professionals (e.g., career center employees and faculty members) so that civil engineering, as an academic field and industry, may recruit more talented Asian women. Internship employers (i.e., professional alter) can offer meaningful social interactions opportunities that Asian women develop while forming their career interests [55], [67]. For example, guest lectures given by industry leaders who are women or people of color may fuel students' interests in civil engineering careers. These leaders can share their work experiences and become a mentor of a student with minority backgrounds to help them navigate their career paths.

Furthermore, near peers (i.e., non-civil engineering alter) can be made aware of the challenges of their Asian female peers and be encouraged to continue to act as an ally in civil engineering. The participants of this study strengthened their motivation to pursue a civil engineering career when they were able to identify and access support from their peers and mentors in class and student organizations. Although some of them were even more aspired to pursue a civil engineering career after interacting with a successful female mentor, it is irresponsible to say that their success is solely on female civil engineers. The goal to create and develop the talented and diverse civil engineering workforce is in the hands of current and future civil engineers. Therefore, this study urges all civil engineers to stand aside with underrepresented minority individuals in this field.

Future work

Future work is in progress to identify and explore the type of cultural capital that Asian women access and activate through their relationships with alters. In this study, name generator and sociogram were mainly used to analyze participants' social network. As part of the larger study, this study will analyze interview transcripts as a primary source of data to explore their interactions and influences on their career interests and aspirations. This next step will elicit more meaningful conversations around cultural capitals that Asian women access and utilize to enhance their career interests in the field of civil engineering.

Furthermore, the frequency of interaction between an alter and a participant will be compared with the degree of impact through data analysis. For instance, the name generator prompted participants to specify how frequently and for how long they interacted with an alter. Participants could place the most powerful alter nearest to their ego (in the innermost circle) and the least powerful alter at the outermost. Future research will compare these two answers to determine what factors Asian American women already engage with enough and what they need more access to in order to impact their decision to seek a career in civil engineering.

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