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EXPERIENCES AND CAREER CHOICES OF FEMALE ENGINEERING UNDERGRADUATES IN CHINA

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ABSTRACT

It is a global issue that the 'pipeline' leading to STEM occupations begins to 'leak' after graduation from STEM subjects, and the leakage tends to be much more severer for women. This study adds to current discussions on the underrepresentation of women in STEM fields, emphasizing the roles of gender and family engineering social capital in the career choices of female engineering students

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in China. The study follows an explanatory mixed-methods research design including a survey and interviews. The survey was completed by 508 Chinese engineering undergraduates at Chinese universities and created a quantitative descriptive landscape that situates the qualitative element of the study. Semi-structured interviews were conducted with 24 female engineering newly graduates to explain the underneath complexities of the quantitative discourse. Descriptive analysis of the survey data shows that women students, on average, tend to report higher engineering agency and more positive university experiences, but a weaker desire to pursue an engineering profession than men. This inconsistency can be partly explained by the qualitative finding that the hegemony of Confucianism shapes the specific gender norms towards engineering profession in China. Qualitative data also suggest that it is the “craze for Master’s degrees” in China that drives a number of women participants to take an MSc in engineering with the intention to work outside this field. However, having a family member working in engineering tends to provide overarching guidance for female engineering undergraduates to continue with an engineering profession.

1 INTRODUCTION

1.1 Background

Women’s underrepresentation in STEM (science, technology, engineering and mathematics) is a global issue, and engineering is one of the disciplines with the largest gender gap in representation. In China, as of 2020, 40.1% of all human resources in science and technology were female, while this percentage for engineering was only 31.7% (CAST and NAIS 2020). The ‘leaky pipeline’ to engineering occupations begins from the transitionary period from university to work and the leakage is reported to be much more severer for female students (Jan and Sean 2012). The transition of women in engineering from university to workplace is thus a crucial stage. This study aims to explore how Chinese female engineering newly graduates make career choices.

1.2 Gender and engineering aspiration

Gender-STEM stereotypes are regarded as an essential element in reducing women’s aspirations in pursuing a career in traditionally gendered disciplines disciplines. Gender stereotyping can be transferred and (re) produced implicitly and explicitly through daily interactions such as schooling and parenting (Beddoes 2021). Specifically, female engineering students at university have to tackle the probability that their performance might confirm the perceived stereotypes of women’s low aptitude for engineering subjects. This allows them to feel pressure against the gender constraints they experience at university. The climate in engineering programs can be chilly for women due to the male-dominated environment (Blickenstaff 2005; Walton et al. 2015). Such an environment can be a powerful structure contributing to women’s attrition in engineering. Family background is also emphasized by existing literature as a factor affecting engineering subjects and career choices of students, as they can be influenced by parents, who act as guides,

role models and powerful agents, via communication and behavioural demonstration (Balakrishnan and Low 2016).

1.3 Post-structuralist understanding of structure and agency

Under the Foucauldian conceptualisation of power and structure, human beings are not simply under-goers of social experiences; instead, they take agentic actions in exploring and manipulating the structural environment. Agency and structure are not dualistic as they shape and are shaped by each other in a spiral, dynamic and conjoined manner of structuration (Fu and Clarke 2020). In this study, I particularly emphasize not merely the role of social constructions, but also how female engineering students interact, in different ways, with the social structures in Chinese societies where Confucian values emphasize highly gendered values and distinct gender roles have been deeply rooted for over two thousand years (Liu 2014). Being aware that structures are not unchanged or deterministic, I adopt post-structuralism to frame my research, regarding structure as fragmented and fluid. I aim at deconstructing processes of becoming by exploring changes socially and culturally constructed.

1.4 Research questions

This research considers engineering students' university experience and their schooling and family experiences as part of their educational biographies. This is because career decision-making is an ever-evolving process and engineering pathways contain a variety of behaviours that can be derived from adolescence and affected by social-cultural norms.

My overarching research questions are:

- How does gender shape Chinese engineering undergraduates' university experience, engineering agency and career aspirations?
- How do Chinese female engineering newly graduates make career decisions to continue or leave engineering?

2 METHODOLOGY

This study adopted a sequential explanatory mixed-methods approach, with a quantitative survey first and qualitative semi-structured interviews following. The survey targets engineering undergraduates from year one to year four at universities in China. It includes questions about students' agency in engineering, university experience and career aspirations. University experience is measured by 6 items which are drawn from the 'Student Persisting in Engineering Survey' (AWE 2007). Engineering agency includes 16 items from the 'Sustainability and Gender in Engineering survey' (Godwin 2014) as well as 'Agentic actions and agentic perspectives of career development survey' (O'Meara et al. 2014). Participants were instructed to rate each item using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

With regard to career aspirations, as the research aims to examine whether engineering students choose to continue in or leave engineering as a profession, it

identifies two distinct catergories of career choices: being inside and outside engineering. ‘Engineering researcher at university/research institutes’ and ‘engineer at enterprise’ were categorized as plans ‘inside engineering’, which are academic, professional and technical. Other types of jobs were categorized as careers and career plans “outside engineering”.

A total of 508 students completed the survey, of which 31.1% are self-idenfied as women(N=158), and 68.9% are self-idenfied as man(N=350). Statistic descriptive analysis of the survey data has been conducted on SPSS.

The interviews included newly graduated female engineering students. The interview protocol covered topics related to 1) family experience, 2) schooling experiences, 3) university experiences, and 4) career aspirations. A total of 24 participants were recruited by the survey and snowball sampling where participants recruited from the survey were requested to refer just one new participant from their personal contacts, to minimize homogeneity and bias, of which 10 were choosing/planning to choose a career inside engineering and 14 outside engineering. Interview data have been thematically analysed.

3 RESULTS

3.1 Quantitative findings

T-tests were conducted to assess whether the means of two independent groups (women and men) were statistically different from each other. For reporting purposes, the level for statistical significance was set at 0.05

In Table 1, we can see that students in engineering programs reported a high level of engineering agency (means between 3.27 and 3.98). In particular, female participants report higher average scores than men students regarding most of the engineering agency measurements. They only report slightly lower scores in items 7, 8, 9 and 12 in Table 1, which are in line with existing literature suggesting that girls tend to have lower interest and lower confidence in learning engineering, as well as weaker engineering subjectivity (see Guo et al. 2015; Petersen and Hyde 2017).

Table 1. Engineering agency t-test results

Engineering agency items	Men Mean (SD)	Women Mean (SD)	P-value
1. I believe learning engineering will improve my career prospects	3.63 (1.075)	3.68 (.891)	.638
2. I believe engineering can help me see opportunities for positive change	3.50 (1.103)	3.60 (.944)	.311
3. I believe learning engineering can make me more critical in general	3.60 (1.100)	3.76 (.848)	.084
4. I believe engineering is helpful in my everyday life	3.56 (1.087)	3.70 (.899)	.116

5. I believe engineering will provide greater opportunities for future generations	3.45 (1.082)	3.64 (.883)	.037
6. I believe a country needs engineering to become developed	3.86 (1.087)	3.98 (.927)	.198
7. My parents/ relatives/ friends see me as an engineering person	3.50 (1.051)	3.35 (.965)	.147
8. I am interested in learning more about engineering	3.49 (1.073)	3.47 (1.001)	.819
9. I believe I can understand concepts I have studied in engineering	3.43 (1.068)	3.34 (.976)	.384
10. Others ask me for help in engineering	3.31 (1.082)	3.38 (.968)	.479
11. I can overcome setbacks in engineering	3.36 (1.060)	3.36 (1.005)	.971
12. My personal abilities/talents “fit” the requirements in engineering	3.47 (1.091)	3.27 (.980)	.043
13. I have been strategic in enhancing my engineering capability	3.39 (1.042)	3.52 (.936)	.169
14. I have intentionally made choices to focus on an engineering career	3.47 (1.056)	3.52 (.956)	.608
15. I have seized opportunities when they are presented to me to enhance my engineering capability	3.55 (1.008)	3.64 (.869)	.317
16. If I face a setback in the way of pursuing engineering, I take strategic steps to overcome the barrier	3.59 (1.025)	3.72 (.911)	.164

Table 2 shows that engineering undergraduates reported relatively positive university experiences, with mean scores ranging between 3.31 and 3.68. It is interesting to learn that female engineering students tend to rate these items higher than male students, in regard to workload, social interactions, classroom climate, group work, teacher-student relationships and role models. These results contrast with the “chilly climate” studies based on Western contexts (Blickenstaff 2005; Walton et al. 2015) and worth exploring in future studies.

Table 2. University experience t-test results

University experience	Men Mean (SD)	Women Mean (SD)	P-value
17. There is a reasonable workload of the engineering classes	3.48 (1.029)	3.54 (.857)	.508
18. I have positive and frequent interactions with engineering classmates	3.53 (.977)	3.57 (.832)	.627
19. There is a fair and inclusive climate in engineering classes	3.63 (.951)	3.68 (792)	.572
20. I often undertake important tasks in group work	3.40 (1.021)	3.41 (.806)	.925

21. Teachers are interested in me and confident in my professional ability	3.31 (1.028)	3.35 (.903)	.629
22. I have enough role models in the same gender, who can inspire me to work inside engineering in the future	3.37 (1.100)	3.49 (.936)	.234

When it comes to career aspirations of being inside or outside engineering, shown in Table 3, there are statistically significant differences between women and men students (p-value<0.01). 60.9% male students plan to choose a professional position inside engineering, while this number for female students is only 46.8%. Meanwhile, there is a higher proportion of female engineering students who do not have an explicit career plan (20.9% compared to 14.9% for male students), indicating a more urgent need on career guidance targeting female engineering undergraduates.

Table 3. Career aspirations crosstab results

			Inside engineering	Outside engineering	Unclear	Not sure	Total
Gender	Men	Count	213	57	28	52	350
		%within Gender	60.9%	16.3%	8.0%	14.9%	100.0%
	Women	Count	74	41	10	33	158
		%within Gender	46.8%	25.9%	6.3%	20.9%	100.0%
Total		Count	287	98	38	85	508
		%within Gender	56.5%	19.3%	7.5%	16.7%	100.0%

Integrating the above findings, we can conclude that women engineering students, on average, tend to report higher engineering agency, more positive university experiences but a weaker desire to pursue an engineering profession than their male counterparts. The interview data can help explain potential reasons for this inconsistency, which will be addressed in the next section.

3.2 Qualitative findings

3.2.1 Gender norms shaped by the hegemony of Confucianism

Strong gender essentialist mindset, gender stereotypes and discriminations shaped under the Confucian discourses have been reflected by participants, especially for those who choose/plan to pursue a career outside engineering. The conventional gender realm in China is asymmetrical with male privilege, and women were encouraged to take the role of virtuous wives and mothers in the service for the harmony of their families (Chiu 2016). Though those values have been gradually criticized, Confucian patriarchal values highlighting gendered values and roles have been entrenched in Chinese culture(Liu 2014).

Being an engineer is generally regarded as a high-paid but demanding job, this leads to both active and passive choices of leaving engineering for women. Regarding of the former, those women tend to be more sensitive to the gendered structures as so that they purposely avoid a “tiring although high-paid job” because they believe they bear less financial burdens:

> Men may be more suitable to engineering, because after all, men are indeed physically suitable for field work; (…) I think that men's pursuit of salary is stronger than that of women, because salary in engineering field is higher than in liberal arts fields……For women, I think it means that girls will not engage in field work or high-intensity manual work for high salaries, but men will. Comparing with salary, men tend not to regard health issue as important as girls do. (Mo, outside engineering)

This confirms the stereotyped gendered labor divisions that women are not motivated to earn money since men should be breadwinners. On the other hand, participants complained about the discriminations towards female jobseekers as a huge obstacle for their possible career path inside engineering.

> I would prefer an administrative position, because I think being a female engineer can sometimes be discriminated, such as in the maternity leave……A woman does pay a little more attention to her family in the future, I think, and then she may have less energy at work. (Hou, outside engineering)

> Just like some Railway company, if you are a girl, it will only let you do some clerical work like data clerk. And for management and technical positions, boys may be preferred. (Die, inside engineering)

In this light, even though female students tend to have more positive university experiences and engineering agency, powerful social and cultural structures, such as gender discriminations in the job market and Chinese traditional gendered roles, constrain their exercise of agency and prevent some women from practicing engineers or being an engineering professional. The gendered career environment in Chinese society can partly explain the differences between "engineering agency" and "engineering career agency", and between "an engineering student" and " an engineering career".

3.2.2 Family engineering social capital

Participants who choose a career 'inside engineering' tend to receive support from social relations during their educational biographies and interactions with social constructions. Parents or relatives who work in the engineering industry, provided emotional and material support from choosing engineering as a subject at university to a career after graduation. This resonates with the findings of Madara and Cherotich (2016) that having an engineer in the immediate family (engineering social capital), has a positive influence on their perceptions of engineering and thus supports their interests in pursuing engineering as a future career.

Xiang's family members motivated and inspired her to continue with engineering as a career after graduation:

> My cousin's aunt works at an engineering design institute and I think this is a job with relatively high social status. At that time, I forgot whether she has a Master's degree or not, but she worked very hard, and there were much more boys than girls in her class at that time, but she was considered the best. Her story inspired me a lot. I want to be a woman like her. (Xiang, inside engineering)

In a more practical and concrete way, Kai's father and cousin, both working in the civil engineering field, assisted her to find a job as a structure designer in an

engineering design institute, when she was struggling with getting a Master's degree offer and the discriminations towards female job hunters in this industry:

> It was my family who helped me find this job, my dad and my cousin. It's hard to find a job for an engineering girl. Taking the design institute I am in now for example, if I only rely on myself, such as my university background and my bachelor's degree, it wouldn't accept me at all. For a girl, only if you have a master's degree or you are from a well-known university with excellent academic performance, I think you then have the chance to be accepted by this institute. That's the status quo. (Kai, inside engineering)

Engineering-related social support tends to empower female engineering students to resist gendered structures and exercise their agency to persist in this male-dominated field.

3.2.3 Degree-driven model of pursuing a MSc in engineering

There is a special group among my participants who (plan to) further their study in engineering but propose to leave this professional area after graduation(N=9). A common justification for their choices is that securing a Master's degree is more significant than choosing a program they are interested in.

> Learning geological engineering means that you can't avoid working in a harsh environment where many people don't want to go, so the competition is not that severe. It's relatively easy to pass the post-graduate entrance examination. This is also one of the reasons why I choose this master program. (Hou, outside engineering)
>
> Everything was on the premise that I could be accepted as a postgraduate student. I didn't have too much loyalty to the choice of subject to learn, as long as I can be enrolled. (Ren, outside engineering)

With the increasingly severe unemployment situation of undergraduates and the trend of "educational inflation" in China, a Master's degree has become the choice of more and more undergraduates. Choosing the same or similar subject as their undergraduate program tend to improve the chance of being successfully enrolled by a post-graduate program. In this case, even if some participants intend to leave this area when landing a job, they still choose to learn engineering for their post-graduate study. This can be interpreted as agentic conformity to the educational structure in Chinese contexts.

SUMMARY

This paper presents how Chinese female engineering students make career choices. Specific cultural gender norms in family and work perform as obstacles to women's pursuit of an engineering career. Together with the influence of "educational inflation" in China, some female participants choose to continue with the academic research training in engineering with the intention to leave this field after getting a Master's degree. Therefore, even though they tend to have more positive university experiences and higher engineering agency, fewer women choose engineering as a profession than men. Nevertheless, the study findings suggest that having family members working in engineering can assist women to resist gendered social constructions. Family engineering social capital can support women's interest and perseverance in engineering education, and help secure a position in this industry.

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