The experiences and career choices of female engineering undergraduate students at Chinese universities: an intersectional study of gender and social economic status

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Abstract

Engineering is one of the STEM fields with the largest gender gap in women's representation. Existing research in this domain largely concerns Western contexts and takes predominantly psychological, quantitative approaches. The issue remains under-researched especially in Global South contexts and from interdisciplinary perspectives. This thesis explores how female engineering undergraduates in Shandong Province, China make post-graduation career choices; and how the choice-making is informed by their educational experiences before and during university study. It focuses on the intersectionality of gender and social economic status (SES) that situates these students' experiences and choices in Chinese society. The research is primarily underpinned by a poststructuralist conceptual framework that theorises gender, SES, intersectionality, and agency as social constructions. This is complemented by a psychological perspective that explains the internal process of how individuals exercise agency.

This study adopts an explanatory sequential mixed-methods research design, starting with a quantitative survey of both male and female Chinese engineering undergraduates (N=607) to understand the statistical landscape of their gendered and classed experiences. It is followed by qualitative semi-structured interviews with newly-graduated Chinese female engineering students (N=24), focusing on socially-situated knowledge of how those students exercise their agency against gender and SES structures in negotiating participation (or not) in engineering careers. The findings suggest that the prevailing Confucian gender norms and the gender monoglossic atmosphere and pedagogy at Chinese universities significantly constrain the experiences and engineering-related career choices of the participating Chinese female engineering undergraduate students. Meanwhile, participating students agentically engaged with available engineering capital embedded in both pre-university and university stages, empowering them to resist culturally normative gender structures and choose a career within engineering. I reconceptualise 'engineering capital' in the context of

Chinese engineering higher education, arguing for developing support for enhanced accumulation of ‘university-based engineering capital’ for female students and low-SES students.

Impact statement

Academically, there are three major contributions of this study to existing scholarship. First, although the underrepresentation of engineering minorities has been long explored by researchers in western countries (Eisenhart & Allen, 2020; Wao et al., 2023), it remains an under-researched area in China, especially for higher education contexts. Besides this, most existing research seldom touches upon the final career choices when students face the crossroad of graduation. Rather, career aspirations are more often investigated by existing literature (Campbell-Montalvo et al., 2023; Thébaud & Taylor, 2021). This study thus first and foremost contributes to international scholarship by providing evidence from Chinese engineering higher education, and from not only undergraduate students but also newly-graduated students.

Second, most existing research explores engineering aspirations through psychological lens and accordingly via quantitative research methods (Tendhar et al., 2017; Verdín, Smith & Lucena, 2021). Qualitative sociological perspectives are largely unexplored. I believe that neither numbers nor narratives alone can fully capture the phenomena under investigation. Therefore, this study contributes to knowledge by considering both sociological and psychological aspects and employing an explanatory mixed-methods approach that provides more nuanced explanations of female engineering students' experiences and career choices.

Third, the concept of 'science capital' has been extensively explored and applied within the contexts of compulsory education in western countries (Cooper & Berry, 2020; Jones et al., 2021), but less is known about whether and how it can influence post-compulsory engineering participation and career choices in Chinese contexts. My study provides a more cultural-sensitive methodological and theoretical reconceptualization of 'engineering capital' for Chinese higher education contexts. It explores how gender and SES intersect to shape female engineering students’ career pathway in China, signposting ways to support participation and empowerment of such students. It also provides new interdisciplinary perspectives to inform future research training in the field.

Considering benefits outside academia, the study aims to impact the education system in China to be more inclusive, resulting in more female engineers and enhancing gender equality in Chinese society. The research findings suggest that elements of engineering and guidance on university subject choices should be embedded into Chinese high school education, so that students, especially female students, can make more informed and confident choices around engineering at university. Additionally, a more gender-sensitive pedagogy and teacher training in both high schools and engineering undergraduate programs is recommended, encouraging female students to participate in engineering practical tasks. Female students would then have more positive, affirming experiences in engineering. This would in turn foster a more gender diversified workforce in engineering in China, contributing to the innovation and competitiveness of engineering and technological development. Importantly, it would support China’s implementation of UN Sustainable Development Goal 5: Gender Equality (2015), ensuring women’s full and effective participation across all areas of life. This empirical evidence from China would also inform inclusive policies in the higher education systems in other countries, so that culturally-sensitive and -relevant initiatives can be developed to support female students in engineering and other STEM disciplines.

Author's declaration

I, Zeyi Liu, confirm that the work presented in my thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Chapter 1 Introduction

1.1 Background

Women's underrepresentation in STEM (science, technology, engineering and mathematics) is a global issue (Fitzgerald & Corrigan, 2021; UNESCO, 2022). For instance, of all human resources in science and technology in China, only 38.9% were women, as of 2017 (China Association for Science and Technology and National Academy of Innovation Strategy, 2020). In 2021, women only accounted for 7.38% of the academicians elected to the Chinese Academy of Sciences (2021) and Chinese Academy of Engineering (2021). In the OECD (Organization for Economic Co-operation and Development) area, 5.5% of men working in all areas were ICT (Information Computer Technology) specialists, compared to only 1.4% of women (OECD, 2017). The 'pipeline' leading to STEM occupations begins to 'leak' after graduation and this leakage tends to be much more severe for females (Meoli, Piva & Righi, 2024; Schwerter & Ilg, 2021). For example, in the UK, 42% male compared to 21% female STEM undergraduates transferred into STEM workplaces in 2010 (Jan & Sean, 2012). Therefore, the transition of women in STEM from university to workplaces has been recognized as a crucial stage by existing research (Ahmed & Churchill, 2021; Dutta, 2019; Smith & Gayles, 2017).

Women's underrepresentation in STEM is an outcome of numerous phenomena, such as publicly-held stereotypical beliefs that males are innately more talented in STEM fields (Archer, Godec & Holmegaard, 2023; Hill et al., 2010), females' lack of interest in STEM (Bloodhart et al., 2020; Lathifa, 2023), gender discrimination in STEM workplaces (Funk & Parker, 2018), a lack of a sense of belonging (Danielak et al., 2014; Xu & Lastrapes, 2022), a lack of confidence (Prieto-Rodriguez, Sincock & Blackmore, 2022), and the pressures of work-life balance (Male et al., 2018). Further details on these issues will be illustrated in Chapter 2.

The overall shortage of labour in STEM fields could be released by bringing more women in (Ahn et al., 2019). This would align with the targets of UN Sustainable Development Goal 5: Gender Equality (2015) to ensure women's full and effective participation in all aspects of life. It is also difficult for STEM organizations with homogeneous workforces to perform effectively in a constantly changing and diverse environment (Varma, Falk & Dierking, 2023). My research aims to address the underrepresentation of women in STEM and explore pathways to support their participation by understanding the socially constructed barriers they face.

Additional to the focus on gender gaps in STEM fields, I explore how gender embeds differently among female students of different socioeconomic status (SES). For example, in China, Guo, Tsang and Ding (2010) found that the gender gap among engineering undergraduates from rural families was 60.2%, compared to 51.3% among urban undergraduates. Studies on science capital (see Section 3.2 for details) also show that women from lower SES backgrounds in the UK tend to have lower science aspiration (Archer et al., 2015; DeWitt, Archer & Mau, 2016). This informs my intention to consider the intersectionality of gender and SES in this research. Throughout this study, SES carries two distinct meanings. First, it represents the rural-urban divide in the Chinese context, reflecting individuals' economic, social, and cultural capital. Second, it refers to science/engineering-specific capital, linking SES more directly to science/engineering disciplines. A detailed explanation of "engineering capital" will be provided in Chapter 10. As I shall illustrate in detail in Section 1.4, SES in the context of my study is an alternative term to social class (Manstead, 2018), reflecting China's socio-cultural and political contexts. SES specifically refers to the urban-rural divide in China, which is a critical variable in my research that impacts female engineering students' access to educational resources and particularly to science/engineering capitals.

1.2 Aims and research questions

My research focuses on the experiences and career choices (both within and beyond engineering) of female engineering undergraduates from different SES background at Chinese universities. First, among STEM disciplines, engineering often exhibits the largest gender gap, but it is frequently overlooked by educators and researchers (Moote et al., 2020). Second, the 'leaky pipeline' for women's engineering careers is particularly pronounced at the university level (Smith & Gayles, 2017). I therefore explore how their career choice decisions are made. Third, China experiences a severe lack of females in engineering (Chinese Academy of Engineering, 2021; Wutongguo, 2018; Xu, Yang & Chen, 2016) in the context of the urban-rural divide, 'Gaokao' system and the one-child policy. Details of the Chinese contexts shaping women's experiences in engineering are provided in Section 1.4.

As noted above, I explore gender and SES because they are intersectional characteristics that co-shape individual dispositions (Archer et al., 2017; Carlone et al., 2015; Simon, Wagner & Killion, 2017). Western studies have evidenced their influence on engineering aspirations (Codiroli, 2015; Moote et al., 2020). However, few such studies are available in China, especially related to career choices: for example, there is only limited evidence on how gender inequity embeds differently between rural and urban areas in China in terms of engineering enrolment (Guo, Tsang & Ding, 2010). Regarding SES, this study also aims to draw on 'science capital' (Archer et al., 2015; DeWitt, Archer & Mau, 2016) as a key theoretical concept to investigate its reconceptualization for engineering disciplines in Chinese higher education contexts.

This research not only considers engineering students' university experiences but also their schooling and family experiences as part of their educational biographies. This is because career decision making is an ever-evolving process (Smith & Gayles, 2017) and STEM pathways can be derived from adolescence and affected by social-cultural norms (Master, Cheryan & Meltzoff, 2015; Wang & Degol, 2013). They draw on the concept of habitus which refers to dispositions formed during early socialization, influencing individuals' perceptions and life choices (Bourdieu, 1977). These biographical histories can lead to various motivations, such as gender-differentiated motivations, for choosing engineering as a major at university and can further shape career choices (Guo et al., 2015; Robnett & Leaper, 2013). In my view, the career choices of engineering undergraduates can be affected by motivations to learn engineering, and these can be shaped by past experiences.

My **research questions** are as follows:

1) How is science capital manifested in engineering disciplines in Chinese higher education?
2) How are Chinese female engineering students motivated to learn engineering at university?
3) What are the experiences of female engineering students at universities in China?
4) How do gender and SES intersect to shape the career choices to continue in or leave engineering of Chinese female engineering newly-graduates?

1.3 Research contributions and significance

The underrepresentation of engineering minorities at university and in the workplace has long been explored by researchers with a focus on gender, SES and race (see Archer et al., 2017; Black et al., 2010; Eisenhart & Allen, 2020; Simon, Wagner & Killion, 2017; Wao et al., 2023). However, most existing research rarely touches upon the final career choice decisions when students face the crossroads of graduation. Instead, career aspirations are more often the focus of existing literature (see Campbell-Montalvo et al., 2023; Thébaud &

Taylor, 2021). The final career choice stage is crucial to explore because it captures an additional stage of job finding, whereas career aspirations may change over time. Importantly, women's underrepresentation has been an under-researched field in China. The small number of existing studies in China mainly focus on the pre-university stage (Du & Wong, 2019; He et al., 2020) and the biased workplace environment (Xu, Yang & Chen, 2016), while higher education is largely neglected. This study, working with Chinese engineering students on graduation, contributes evidence from China on the complexities of how gender and SES intersect to shape female engineering students' negotiations of their career choices. Chapter 2 has more detailed illustrations in terms of engaging with existing literature. Specific Chinese contexts will be described in the next section.

Second, most existing research explores engineering aspirations through a psychological lens, such as self-efficacy, task value and expectancy (see Smith & Gayles, 2017; Tendhar et al., 2017; Tzu-Ling, 2019; Verdín, Smith & Lucena, 2021). Accordingly, quantitative research methods are frequently applied to exploring the individual factors that impede women, lower-SES students or other minorities from entering engineering disciplines or workplaces. Gender, SES, and race are often theorized as positivist variables in such studies, which risks reproducing gendered, classed, and/or racialized structures rather than challenging them. Qualitative sociological perspectives, such as how social constructions and structures influence their choices and how individuals perceive themselves within a specific social field, are largely neglected. A quantitative approach alone also overlooks how these cause and effect processes happen, leaving the socially-constructed nature of gender, race and SES unexplored. This study advances knowledge by considering both sociological and psychological aspects and employing an explanatory mixed-methods approach that can provide more nuanced explanations of female engineering students' career choices. Chapter 3 will further elaborate on this point.

Lastly, this study aims to challenge the intellectual dominance of the Global North in this field. The concept of 'science capital' has been overwhelmingly explored and applied within the contexts of compulsory education in Western countries (Cooper & Berry, 2020; Jones et al., 2021; Moote et al., 2019b), but less is known about whether and how 'science capital' can shed light on post-compulsory engineering participation and career choices in other Global South contexts such as China. Importantly, among STEM disciplines, the engineering discipline has received relatively little attention in the application of 'science capital'. More recently, Cannaerts and colleagues (2023) have conceptualised 'engineering capital' in Belgium by mainly transferring 'science' related aspects into 'engineering'. They (ibid) highlight the significance of making a distinction between students in higher education and secondary education regarding the level of engineering capital obtained. My study provides a more culturally sensitive and comprehensive methodological and theoretical reconceptualization of 'engineering capital' in Chinese higher education contexts. Its contributions mainly include the conceptualisation of 'university-based engineering capital' and 'gendered engineering capital' (see Chapter 10). Also, the theory of gender monoglossia and heteroglossia (Francis, 2012) have received limited attention in gender-related and engineering-related research in China (see Chapter 2). This study critically applies this theory into Chinese contexts and explores its manifestations in conjunction with traditional Chinese gender cultures.

Overall, this research contributes to the academic scholarship in three main aspects: 1) providing empirical evidence from female students in engineering higher education in China, and from newly-graduated students; 2) considering both sociological and psychological influences and employing a mixed-methods research approach; and 3) reconceptualizing 'engineering capital' to investigate women's underrepresentation in engineering in China from an intersectional lens, and applying gender monoglossia and heteroglossia (Francis, 2012) into Chinese contexts, potentially challenging the intellectual dominance of the Global North in this field.

1.4 Chinese contexts

This section introduces Chinese-specific contexts related to gender, SES and education. Gender inequality is persistent in China. The Global Gender Gap Report 2024 shows that China ranked 106 out of 146 countries in a composite index indicating national gender equality in economics, politics and education (World Economic Forum, 2024). This can be largely attributed to Confucian values, which have been deeply embedded in Chinese culture for over 2,000 years. These values emphasize highly gendered norms and distinct gender roles (Liu, 2014; Skromme Granrose, 2007). Women are not encouraged to have a demanding career, such as being an engineer, as they are expected to undertake major domestic responsibilities alongside work outside the home. Efforts towards gender egalitarianism in China have been made through policy enacted by those in administrative and leadership positions. Specifically, legal provisions including the Marriage Law (1950) and the Chinese Constitution (1954) guarantee equal rights for women, while the government-led institution, the All-China Women's Federation, actively promotes equal participation in social and political activities for women.

Although the Communist Party of China initially promoted gender egalitarian policies, this progress has slowed since the market reforms in the late 1970s (Liu, 2014). During these reforms, the public childcare system began to shrink, and child-rearing responsibility was released to the family – more specifically to women (Sun & Chen, 2017). This has become a persistent obstacle to women's career development. Since engineering is regarded as a tiring and demanding job, social pressures on female engineering students to pursue an engineering career can be even harsher. The gender hierarchy has never fully disappeared but has changed in form over time, from denying access to schooling to implicit and explicit stereotypes embedded in daily life and education experiences (Huang & Placier, 2015).

Before introducing the Chinese contexts of SES, I first justify my position of using the term ‘SES’ rather than ‘class’ in my research. The Chinese Communist Party has promoted a socialist market economy since the ‘Reform and Opening-up’ in the early 1980s, and the class discourse constructed by Premier Mao was rapidly shattered in the face of the aim to achieve socialism with Chinese characteristics (Pan & Chen, 2008; Zhong, Wang & Yin, 2020). The framing of socioeconomic divisions in China has been influenced, with a preference for promoting social cohesion rather than highlighting class divisions. In effect, the lived experiences of class are apparent in China, yet class discourse is severely suppressed (Pan & Chen, 2008). Although the term ‘class’, such as in working class and middle class, is not officially used in China, hierarchical social categories in terms of SES are acknowledged by the public and government, such as the urban/rural division, skilled and unskilled workers, and wealth inequalities. Besides the specific conditions in China, Manstead (2018) claims that SES and social class can be used interchangeably in modern research. Therefore, I tend to regard SES and class as equivalent in my theorization.

China is a developing country with huge economic inequality, especially between urban and rural areas (Liu, 2020). It has a distinct class system where the ‘hukou’ system (Household Registration System) categorizes, by law, citizens into either urban or rural groups (Mu, 2018; Vickers & Zeng, 2017). Rural families often face fewer educational resources and a more disadvantaged SES compared to urban families (Xie & Zhou, 2014; Zhao et al., 2014). Families with different SES also tend to hold differential gender values. For example, parents in rural areas are more likely to have higher education expectations for sons than for daughters, compared to parents in urban areas (Hannum, Kong & Zhang, 2009; Wang et al., 2020). In contrast, female students from higher SES families in China are more likely to adopt a mindset that challenges gender stereotypes and pursue STEM careers (Liu, 2020).

The urban-rural gap is further exacerbated by the ‘one-child policy’ that was in effect from 1978 to 2015. This policy stated that each Chinese couple was allowed to have only one child, although its implementation varied regionally (Xu & Woodyer, 2020). Since the traditional preference for sons is prevalent in lower SES families and in rural areas (Chen & Wang, 2013), the ‘one-child policy’ in this regard enlarged the urban-rural gap and affected girls’ experiences in particular. This policy led to increased investment on girls’ education when they were the only child; however, this was more likely to occur in urban areas and in higher SES families. Although the one-child policy was abolished in 2015, it is still worth considering because the vast majority of current undergraduates were born in the one-child era. When it comes to employment, the implementation of the ‘two-child policy’ from 2016 and the ‘three-child policy’ issued in 2021 provides more difficulties for women in securing a job and getting promotion due to multiple periods of maternity leave, especially in male-dominated workplaces (Xu & Woodyer, 2020; Gao, Zhao & Chen, 2024). These policies can discourage female engineering students from choosing to work in engineering, a field that always disadvantages female jobhunters (Xu & Yu, 2013).

After introducing gender and SES imbalances in China, education conventions are briefly mentioned here. Under the ingrained influence of Confucian philosophy, some traditional values are reflected in Chinese education, such as ‘filial piety, respect for the elderly’, authority of teachers and the emphasis of harmony (He, 1996: 3). The teacher-dominated pedagogical method that has been prevalent in most Chinese schools and universities (Ye, 2011) has failed to provide an enabling learning environment for engineering, a discipline that requires practical application and innovation (Chiu et al., 2013). Moreover, schools and teachers are less likely to encourage girls’ choices and persistence in STEM undergraduate programmes, reflected in the lack of girl-oriented science-related activities and pedagogies in classrooms (He et al., 2020). Furthermore, compared to urban schools, the teaching of science courses in rural schools and the development of students’ science abilities remains at an inferior level (Qiao & Zhou, 2020).

Some endeavours have been made to enhance engineering higher education and encourage women's participation in professional engineering jobs. In 2017, China's Ministry of Education launched the 'New Engineering Education' initiative to systematically improve the country's undergraduate-level engineering programmes, including upgrading teaching and assessment methods and fostering greater faculty-student interactions (Zhuang et al., 2020). Also, the Ministry of Science and Technology of the People's Republic of China (2021) issued 'measures to support female scientific and technological talents to play a greater role in scientific and technological innovation'. These efforts may help to reduce the pressures faced by female engineering students when considering a career within the engineering field.

Below, the 'Gaokao' system, which serves as a unique university admission process in China, is explained in detail. Shortly after the establishment of the People's Republic of China, independent admissions for all colleges and universities were terminated, and a nationwide unified university admissions system was adopted in 1952 (Wang & Xu, 2022). To be admitted to universities, students need to take the College Entrance Examination ('Gaokao'). The system of admitting students according to provincial quotas was implemented, which means that universities allocate admission quotas to each province and, within the scope of each province, conduct admissions based on the admission plans, the 'Gaokao' scores of candidates and their preferences (Davey, Lian & Higgins, 2007). The basic admission process here is somewhat different from in many Western countries; candidates are ranked based on their 'Gaokao' scores rather than having a fixed passing threshold. When filling out university application forms, students are allowed to choose multiple programmes and universities, and to choose whether they are willing to accept allocations made by universities to increase their chances of being accepted (Chen & Gao, 2011). This allocation process is named 'tiaoji' in Chinese. This process is similar to the 'clearing' period in the UK where universities can open up remaining spaces for those who fail to get into their first choice. The difference is that the UK 'clearing' process is more student-driven, allowing students to actively select available opportunities, while in China, universities assign a major to students during the ‘tiaoji’ process, who then decide whether to accept the offer. Students who accept ‘tiaoji’ are named ‘the major transferred undergraduates’ in English. This thesis adopts the criteria of Chen and colleagues (2015) who define ‘the major transferred undergraduates’ as those students who do not pursue their top-preferred programme. The ‘Gaokao’ system has significant implications on higher school education and subject choice at universities. Chapter 7 will elaborate on how this is related to engineering choices.

1.5 Structure of the thesis

This thesis contains 10 chapters. Chapters 2, 3 and 4 provide the theoretical framework of the study and literature reviews on relevant theoretical and empirical research. Chapter 5 introduces the explanatory mixed-methods approach employed by this research. Chapter 6 presents the quantitative findings and Chapters 7, 8 and 9 are qualitative findings chapters. Chapter 10 combines the discussion and conclusion, mainly providing answers to the four research questions and situating the findings within the existing literature.

Chapter 2 presents my theoretical understandings of gender. The beginning of this chapter establishes that the study is conducted from the perspective of post-structuralism by introducing Foucault’s concepts of power. Then the relevant gender theories are discussed critically, including the traditional debates on biological determinism and social determinism, gender monoglossia and heteroglossia, gender performance and public patriarchy. My overall understanding of gender being socially constructed is integrated into these discussions. The second half of this chapter presents empirical evidence in existing literature of gender-related social constructions on female engineering students.

Chapter 3 addresses intersections of SES with gender in engineering or similar fields. I first present my post-structuralist understandings of SES by critically analysing Bourdieu’s concepts of capital, habitus and field, which are frequently interpreted as structuralism.

Section 3.2 details the concept of 'science capital' developed by Louise Archer and her colleagues as an aspect of SES specifically in the domain of STEM/engineering. Then, the theory of intersectionality is presented to theorize gender and SES together. The last section reviews literature regarding empirical research on the influences of SES and gender in engineering experiences and career choices.

Chapter 4 first theorizes agency from not merely a sociological perspective but also a psychological one. Then, the non-binary interactions between agency and structure are illustrated. Sections 4.3 and 4.4 address psychological understandings of agency based on reflexive agency and social cognitive perspectives. Social cognitive career theory (SCCT) is presented as a justification of my own theoretical framework, which is presented in the summary section. This chapter also references empirical research on how agency interacts with social structures related to gender and SES to shape engineering choices.

Chapter 5 elucidates my ontological and epistemological positions underpinning the design of a sequential explanatory mixed-methods approach. Sections 5.2 and 5.3 detail the process of quantitative and qualitative parts, including the design of survey and interview schedules, the sampling and recruitment of participants, data collection and data analysis. The end of the chapter presents the ethical implications, self-reflexivity as the researcher, and potential limitations of the research design.

Chapter 6 presents the quantitative findings from the survey concerning respondents' demographics, science and engineering-related experience and beliefs before university, subjective beliefs in engineering, university experience and career aspirations. Data cleansing and data analysis techniques are first demonstrated. Section 6.3 presents the demographic statistics, which also helps to verify the diversity of the respondents. Section 6.4 constitutes a distinct section dedicated to reporting the findings regarding 'the adapted science capital index' within the context of my study. This contributes to the reconceptualization of ‘engineering capital’ in Chapter 10. Then, the statistical data are analysed by gender and SES in more detail through Crosstabs with Pearson’s chi-square test and Independent-samples t-test. Section 6.7 discusses the findings derived from the analysis of open-ended questions. Findings in this chapter provide a statistical landscape that situates the qualitative results, and the qualitative findings in Chapters 7, 8 and 9 serve to explain the statistical patterns.

Chapter 7 sets out the study’s qualitative findings on Chinese female students’ motivations to learn engineering at university. It primarily explains how gender and pre-university engineering capital intersect to make a difference in shaping the agentic subject choices of female engineering students under the specific educational system in China, namely exam-oriented high school education, the university admissions system and the perceived superiority of science over arts.

Chapter 8 discusses three emergent themes regarding the university experiences of female engineering students. Being influenced by the gender segregation in classrooms, gendered assignment of practical tasks and gendered assessments in engineering programmes at university, gender appears to become a ‘regime of truth’ that conditions how female students see themselves in engineering. A diminished sense of belonging, self-efficacy and interest in engineering appears to result from a gender heteroglossia. At the end of this chapter, I list participants’ suggestions for ways in which engineering undergraduate programmes might become more inclusive to female students.

Chapter 9 presents complexities regarding the career choice process of female engineering students. Internship is often regarded as augmenting their previous attitudes and dispositions towards engineering. Gender discrimination in the job market and parental discouragement from pursuing a demanding career are then illustrated as major obstacles for female students’ choice of career within engineering. In contrast, engineering capital embedded within family and university is shown to empower female engineering students to pursue a career in engineering. Section 9.5 identifies the issue of a lack of ambition around becoming an excellent engineer among those making career choices in engineering. Finally, differences among various engineering sub-disciplines are acknowledged.

Chapter 10 combines the discussion and conclusion with more synthesized and explicit responses to the four research questions, discussing the reconceptualization of ‘engineering capital’, motivations to choose engineering programmes, university experiences and career choices. Finally, the chapter discusses practical implications, limitations of this research and corresponding suggestions for future research.

Chapter 2 The role of gender in framing engineering aspirations

Chapters 2, 3 and 4 aim to integrate theories and empirical studies concerning gender, SES and agency, which constitute the essential foundation and theoretical framework for this research. I particularly emphasize the influence of social structures, including gender norms and unequal SES distributions, on female engineering students and how they response to these influences in different ways. By rejecting the notion of an independent and hidden 'truth' underlying the social structures, I am aware that social structures are not unchanged or deterministic (Holmes, 2007). I argue that the regime of 'truth' and its associated structures of hierarchy (such as men over women and higher SES over lower SES) need to be challenged for a just society.

In this chapter, I first draw on key theorists such as Michel Foucault, Raewyn Connell, Rebecca Pearse, Becky Francis, Judith Butler and Sylvia Walby to fortify my theorization and understanding of gender. It is acknowledged that not only the theories I draw on in this chapter but also current worldwide gender theories re predominantly generated from the Global North (Banerjee & Connell, 2018). Innovative works in the Global South often consider different social-cultural contexts, in combination with critical engagement with Northern ideas (Connell, 2014). I thus fully take into account the Chinese contexts when engaging with theories from the Global North. I then demonstrate the role of gendered social structures on female engineering students in different settings and at different stages of life, by drawing on empirical evidence from around the globe, including China. I also re-analyse and interpret this literature through the lens of my theoretical considerations.

2.1 Starting with Foucault's concept of power from a post-structuralist perspective

This section draws on Foucault's concept of power in understanding gender and SES as both social structures that situate agency. Though this section is placed in the chapter on gender, it touches upon key concepts in this study as foundations.

Regarding social structures as fragmentated and fluid, I use post-structuralism to frame my work, which aims to deconstruct processes of becoming by exploring how they are socially and culturally constructed (Kwa, 2002; Hillier, 2012). Foucault is one of the most predominant sociologists in the move towards post-structuralism, especially in terms of the sociology of gender (Holmes, 2007). His theorization of power and knowledge contextualizes the landscape in which my research is situated. Within a complex interwoven structure, power can be dispersed in diverse ways, subject to the various positions we assume over the course of our lives (Clarke, 2006). I advocate Foucault's (1977, 1980) argument that certain forms of knowledge work to generate social norms that can be dominant in shaping subjects' perceptions and actions through the play of power in historical and social processes. Power is often masked, because when knowledge becomes ideology or the so-called 'truths' people hold implicitly, we tend to take power structures for granted (Foucault, 1977; MacNaughton, 2005). If power is consistently exercised in a particular manner, it can eventually become standardised or normalized. In the domain of engineering, there may exist an implicit assumption that men are inherently better suited for this profession, resulting in it being accepted as a regime of 'truth'.

However, those so-called 'truths' are neither fixed nor universal; instead, they are subject to social and cultural changes (Foucault, 1980; Downing, 2008). Therefore, the naturalness of our bodies is meaningless without being understood in historical and social contexts (Foucault, 1977, 1978). The power of social structures has implications for the comprehension of gender, which also ought not to be viewed as a mere reflection of an inherent, self-evident (biological) category that exists as a natural state. The meaning of how bodies relate to gender is thus constructed by social structures, which will be depicted in the next section. SES (see Section 3.1) is similarly not an inherent or objective characteristic, but a product of social structures and systems of meaning.

Foucault (1977) stated that power does not derive from a singular origin but rather is characterized by fluid and dynamic power relations. Foucault (1982) defined power relations as a mode of action which influences the existing or future actions of others. Power relations are deeply rooted in the system of social nexus, but power does not equate to a renunciation of freedom. It means that individuals or collective subjects who are in the middle of power relations have a certain field of possibilities in which several ways of behaving and reactions can be realized. 'The recalcitrance of the will and the intransigence of freedom' constitute the essence of power relationship (Foucault, 1982: 15). Therefore, under the Foucauldian conceptualisation of power relations, individuals have agency (see Chapter 4) in their interactions with powerful and shifting structures. Agency is socially constructed, subject to the fluid social structures that situate individuals in particular times. Meanwhile, agency can, in turn, affect the structures, indicating that they are not dualistic.

In this research, I focus on how gender and SES are both social structures that situate agency and impose powers on female engineering undergraduate students' career choices in particularly Chinese contexts. Foucault (1982) also posited that power relations have increasingly come under state control and different countries tend to follow diverse patterns in educational, judicial, financial, or family systems. For example, in the comparative research conducted by Xu, Schweisfurth and Read (2022), they emphasized how Scotland and China, as two different contexts in the Global North and South respectively embedding distinct gender norms, affect the inclusion of men in early childhood education and care. Lin and Zhao (2023) also suggest that applying Foucault in Chinese contexts needs to consider factors beyond the concepts themselves, such as the Confucian cultural-historical implications. Therefore, I believe that China, with its socialism featuring Chinese characteristics such as Confucianism, can provide new insights into applying Foucault's ideas to address women's underrepresentation in engineering.

In addition to Foucauldian theories, being context-sensitive is essential in the application of theory, as the development of a theory is shaped by complex connections with its contexts (Whetten, 2009; Chen, Wang & Wang, 2023). With the Global North dominating current knowledge-building processes around the globe, Global South nations such as China require a more nuanced application of Western-based theories (Connell, 2014). Theories employed in this thesis predominantly originate from the Global North, so I remain mindful of the Chinese contexts when engaging with them.

2.2 Understanding gender as being socially constructed

When adopting Foucault's ideas in gender studies, gender is regarded as one aspect of the regimes of 'truth' that is practiced through power in societies. In this case, I uphold that gender is not biologically determined nor can it be overwhelmingly socialized; instead, it can largely be constructed through various social norms and structures, with implications for human beings' perceptions and behaviours (Xu, 2018). In other words, individuals perform their gender based on or against the social script, resulting in different experiences and choices. In turn, existing social structures can also be challenged by accumulated individual and collective performance against these constructions.

2.2.1 Traditional debates on biological determinism and social determinism

To explore the relationship between gender, body and social structures, it is essential to first distinguish between the concepts of sex and gender. Sex refers to anatomical and biological differences, while gender is defined by sociologists of the 1970s to describe socially and culturally produced ways of acting (Goffman, 1979; Holmes, 2007). A long-standing opinion that permeated various societies globally was that ‘natural’ differences lead to different social patterns of gender (Connell & Pearse, 2015). This biological determinist stance assumes that there exist certain essential traits derived from the sexed bodies of individuals, serving to distinguish men as men and women as women – regarded as gender essentialism (Prentice & Miller, 2006). Biological determinism can discourage women from pursuing engineering, as they are often essentially viewed as unsuited for the field.

Social norms are instrumental in shaping distinct gendered patterns within society. For example, it is not women’s inherent fertility that makes them nurturing, but rather the social expectations that largely dictate them to be nurturing rather than aggressive (Le, Pekosz & Iwamoto, 2020; Rudman & Glick, 2021). It is the gendered allocation of labour in family and society that extensively designates women as responsible for unpaid domestic tasks such as childrearing and thus deprives them of the time and energy needed to carve out their careers (Gül, 2020). Furthermore, the way our bodies grow and function is also affected by social processes. For example, women’s generally smaller bodies might be seen as amplified by centuries of male domination where women are often allocated and expected to eat less and stay slim (Rymarczyk, 2021). The smallness of women may partly be passed on genetically but will be enhanced by sociocultural norms and expectations. Women’s so-called physical weakness associated with their biological body seems to work as a perfect excuse for engineering companies to refuse female jobseekers. More empirical evidence on how biological determinism affects engineering experiences and choices will be provided in Section 2.3.

On the other hand, social structures do not mechanically dictate how people act, which is the flaw of social determinism, such as gender socialization theory (Oakley, 1972) and is no more defensible than biological determinism. I appreciate Oakley’s efforts in avoiding conventional thinking about women through their bodies, but she tends to regard sexed bodies as a tabula rasa upon which socialized gender is inscribed (Gatens, 1991). If gender socialization was as potent as suggested, greater homogeneity would be expected among individuals. Additionally, social norms regarding gender can sometimes be ambiguous, and even when explicitly defined, the reality is that not all women adhere to them in the same manner. Individuals tend to exercise their agency in different ways to make different responses to the social structures, which will be the focus of Chapter 4.

Therefore, in my view, gendered bodies can be seen as natural biological entities upon which social-cultural meanings are inscribed. Our gender practices and subjectivities are strongly though not passively constructed by gender relations under the societal structure. ‘Subjectivity’ rather than ‘identity’, which is a term argued by Hollway (1984) to be more frequently used by psychologists, will be used in my thesis to describe findings on how participant students view themselves in relation to engineering and gender. Blaise (2005) defined subjectivity as how individuals consciously or unconsciously relate themselves to the social world, such as beliefs, values and personal experiences. Gender as a concept concentrates on how social elements such as social institutions, not biological bodies, construct people’s behaviours and subjectivities. Inequalities can be overcome because they stem from social processes rather than being purely biological. Connell and Pearse (2015) claim that gender can be neither reflected in simple differences nor fixed categories, but is instead connected to relations, behaviours, subjectivities and boundaries that are actively generated in social processes. Their perspective on gender fluidity is a prominent ideology in the Global North, but in China studies indicate that gender essentialism still largely persists among the public (Ching et al., 2020; Liu, 2014; Yang, 2023).

The discussions in this chapter so far largely focus on dominant gender structures but neglect those who cross these boundaries. In this regard, Francis (2012) provides a meticulous and inclusive illustration by extending ‘monoglossia’ and ‘heteroglossia’ (a language theory developed by Bakhtin) to the domain of gender understanding.

2.2.2 Gender monoglossia and heteroglossia

In the monoglossic gender system, a dominant binarized gender matrix works with its relational ascriptions of features as masculine or feminine (Francis, 2012). Gender monoglossia is ubiquitous and inescapable. For example, individuals tend to be categorized into the two sides of gender binaries in most societies. This is related to gender segregation, which emphasizes the ‘natural’ inclinations, characteristics and abilities of males and females (Charles & Bradley 2002). However, as Thorne (1993) observes, these gender differences are situational and can be ignored or overridden in some cases, such as when boys and girls get involved in cross-sex interactions. Thus, gender monoglossia looks stable at the macro level, but at the micro level, diverse heteroglossia occurs in the form of parody and dissonance in relation to gender normativity (monoglossia). Such heteroglossia is fluid and can change along with times and spaces. It exists in all productions of gender subjectivity to varying degrees. However, any alternatives beyond the dominant, heterosexual practices may be purified and eradicated to achieve the complete hegemonic power of this monoglossia (Francis, 2012). Sauntson (2012) argues that anyone who transgresses gender boundaries tend to be emotionally and even physically punished. This is how the monoglossic, binary discourses of gender serve to mask and stigmatize heteroglossia. In educational contexts, students are likely to be segregated with their same-sex peers (Carter, 1987; Martin, Fabes & Hanish, 2014). Female students tend to be discouraged in multiple ways to step into engineering, as it is essentially regarded as a man’s field.

As demonstrated in her discussion of gender monoglossia and heteroglossia, Francis (2012) shares a perspective similar to Connell’s (2005) understanding of masculinities: when referring to masculinities, one is discussing gender relations rather than solely men themselves. In other words, the term refers to the practices and behaviours of individuals and groups that relate to their position within a gender hierarchy, which is not equivalent to males as a biological category. These actions and conducts are primarily associated with men but may also be observed in women and LGBTQ+ groups. Masculine and feminine gender should be analysed as distinct from sexed bodies, meaning that men can demonstrate femininities and women can model masculine attributes (McGrath et al., 2020; Tarrant et al., 2015). When male masculinity and female femininity equate to monoglossia, female masculinity and male femininity manifest the situation of heteroglossia. It is important to note that the limited discussion of LGBTQ+ groups here is not due to the upholding of a belief in a gender binary. I acknowledge as a limitation in Section 5.5 that this study does not explore LGBTQ+ groups due to the limited sample size.

It is important to question such monoglossia of gender experiences that are constrained and solely based on sexed bodies. According to Connell and Pearse (2015), gender (masculinity and femininity) may have a primary influence on the development and embodiment of bodies, shaping the ways in which individuals live and interact within society. Poststructuralism goes beyond traditional gender discussions that rigidly categorize individuals into distinct gender roles on the basis of materials. Instead, it examines how individuals form their gender subjectivities in relation to established gender discourses (Xu, 2018). Female engineering students in a male-dominated environment can possibly develop or strengthen their masculinity. This study views them as gender heteroglossia crossing the boundaries of monoglossic gender norms, with detailed illustrations to be provided in Chapters 8 and 10. Besides, gender monoglossia and heteroglossia have received very limited attention in China-related research, which is one of my study's contributions.

2.2.3 Gender performance

According to the dramaturgical approach to gender, people are social actors who often work to present a polished display of femininity or masculinity based on gendered scripts

(Goffman, 1959; Gagnon & Simon, 1973). This approach conceptualizes interpersonal social interactions as performances influenced by the surrounding environment and the expectations of the audience, with the objective of conveying impressions that align with the actor's intended objectives. I value Goffman's endeavour in the deprivation of gender from the sexed body, but by focusing primarily on micro-level interactions and the presentation of self, the macro-level influences on social behaviour, such as social norms, ideologies, and institutional practices, may be undervalued (Risman, 2004; West & Zimmerman, 1987).

Gender performativity, as conceptualized by Judith Butler (1990; 1993), expands upon the dramaturgical approach by highlighting that gender is not solely performed but also constructed through repetitive and stylized social behaviours and language. This theoretical framework challenges the notion of gender as an innate or fixed identity. Instead, it posits that it is a continuous performative process of iteration whereby individuals embody and enact societal norms and expectations through their actions, gestures, and appearances (Butler, 1990; Davies, 1993). Halberstam (1998) draws on Butler's theories in her work on female masculinity, offering a profound challenge to the automatic assumption that men perform masculinity and women perform femininity. Influenced by the concepts of 'compulsory heterosexuality' (Rich, 1983) and 'heterosexual contract' (Wittig, 1992), Butler (1990) argues that gender is routinely performed and constructed through a 'heterosexual matrix'. Butler employs the term 'heterosexual matrix' to designate the presupposed hegemonic discourse that normalizes the natural connection between body and gender, with hierarchy and opposition being reinforced through the compulsory practice of heterosexuality.

Foucault's conceptualization of power can be effectively combined with the notion of gender performativity in a 'heterosexual matrix'. I recognize that the gender-related ideas and behaviours we commonly accept are indeed shaped by underlying invisible mechanisms of heterosexual power. Individuals cultivate a sense of gender consciousness within the invisible power dynamics present in educational institutions, family environments, and workplaces where disciplinary power operates. They engage in performances dictated by repetitive external influences in order to conform to societal expectations and appear ‘natural’ as gender monoglossia. Over time, these monoglossic gender norms and stereotypes become internalized, as individuals self-regulate their adherence to the constructed notions of gender. In this case, women may internalize societal expectations and conform to gendered roles that limit their engagement in scientific disciplines traditionally dominated by men (Gunderson et al., 2012). However, female students majoring in engineering have the potential to disrupt the heterosexual matrix by taking on interrupted roles traditionally assigned to females as a binary group.

While both gender norms and stereotypes were mentioned above, in this study I mainly focus on gender norms as this term can be more original and foundational in addressing gender equality issues. The social rules and expectations that regulate proper behaviours of women and men in order to protect the existing gender system intact can be defined as gender norms (Connell & Pearse, 2014; Cislaghi & Heise, 2020). Gender stereotyping refers to certain representations of individual characteristics, behaviours, studies, occupations and lifestyles that are regarded as specifically suitable for men or women (Connell & Pearse, 2014; van Tuijl & van der Molen, 2016). I uphold that the repetitive practices demonstrated in the surroundings embedded with gender norms can gradually result in gender stereotypes, creating a landscape in which individuals perform gender. Gender stereotypes can uphold and perpetuate gender norms by exerting influence over individuals’ perceptions of themselves and shaping social expectations regarding gender roles. Gender stereotypes hence often become vehicles for gender norms (Connell & Pearse, 2014).

From my theoretical perspective of gender, gender norms are regarded as socially constructed and powerful structures shaping individual gendered experiences. Different gendered patterns can be more about the consequences of social structures. Proficiency in engineering and sciences, and the devotion to lucrative careers rather than unpaid domestic responsibilities, are commonly associated with men. This phenomenon can be attributed to the prevailing power dynamics within patriarchal societies, where men predominantly occupy positions of power and influence (Gilligan & Snider, 2018; Beck et al., 2022). Consequently, the prevailing discourse, which is largely shaped by men's perspectives, perpetuates and reinforces male-dominated social structures. This is how gender norms consistently disadvantage women. Therefore, I regard gender norms in engineering domain as a form of problematic social constructions that can impose negative impacts on female engineering students' persistence in this field.

Within Butler's framework, agency also assumes significance as individuals possess the capacity to actively participate in both conforming to and subverting gender norms ('doing' and 'undoing' gender) through their performative acts (Butler, 2004). The concept of performativity requires constant repetition, thereby creating opportunities for introducing differences within the process, and these moments of deviation and interruption within repetitive acts are regarded by Butler as the locus of agency (Clare, 2009). Making agentic choices to conform to gender norms may result in the erasure of one's individuality, while resisting gender norms can come at the cost of personal persistence and survival (Butler, 2004). The latter resonates with how gender heteroglossia may lead to emotional and, in some cases, physical repercussions (Sauntson, 2012). Women who engage in the field of engineering and pursue careers in this domain as gender heteroglossia can thus often encounter challenges as they navigate the gendered structures within the field.

Butler's concept of gender performativity acts as a helpful instrument underlying my research, but it may overlook the intersectional nature of gender. It seems that it does not adequately address the ways in which gender identities are shaped by other social categories such as race, class, sexuality, and disability. This reinforces my decision to incorporate SES as an intersecting factor that influences the experiences and career choices of women studying engineering. Chapter 3 of this thesis will present more in-depth examples and analyses to elucidate this particular aspect.

This section critically examines gender performativity, the heterosexual matrix and gender norms. I hold that when being implicated by agency, our gender performance is strongly but not passively shaped by monoglossic gender norms in certain times and spaces. In this case, a number of female students choose to learn engineering, a counter-traditional discipline for women, and finally make different career choices of being inside or outside engineering. Section 2.3 will provide further empirical details on this complex process. It is worth noting that the gender scripts regarding STEM can vary from region to region. For example, the percentage of women students enrolled in STEM in higher education experiences a significant national variation, ranging from 16% in the Ivory Coast to 86% in Bahrain (UNESCO, 2017). This reflects the fluidity of structure and a justification of my choice of China for this research. The theories discussed in this section, especially gender performativity, have been widely applied and proven to be effective in Chinese gender research with the intention to promote gender fluidity and disrupt the binary gender system (see Madsen, 2011; Liu & Li, 2020; Tsang 2021; Yang 2023). Additionally, the public patriarchy in China can account for women's choice of leaving engineering.

2.2.4 Public patriarchy

Walby (1990) introduces the concept of public patriarchy, indicating the situation that leadership positions in public spheres are dominated by men. Walby claims that as more women enter the job market, gender relations have gradually moved from private patriarchy within the family to public patriarchy. In the job market, there is often an expectation that women as a group are required to balance work and family responsibilities, while men can dedicate themselves to advancing their careers and seek leadership positions without much concern in relation to their family (Male et al., 2018; Aarntzen et al., 2023).

Against the backdrop of public patriarchy in China (Walthall, 2020), societal preferences of gendered roles constrain women's behaviours, mentalities and choices. For example, women tend to be socially encouraged to find stable and less demanding jobs, even if the pay is low. The underlying logic of this norm is the gendered role of men and women in a family when women tend to be assigned to caring responsibilities and housework. This can be a reflection of how private patriarchy is related to public patriarchy in China. Under the entrenched influence of Confucianism, although Chinese women are no longer fully expected to stay at home in modern society, they are not encouraged to dedicate too much of their energy to pursuing a successful and demanding career outside the home (Woodhams, Xian & Lupton, 2015), such as being an engineer or leader.

It appears that within patriarchal structures, regardless of women's capabilities, men often exert control to maintain their dominance in terms of power, status, and wealth in the public sphere. For example, women are often expected to cook at home, while high-end restaurants are typically dominated by male chefs (Harris & Giuffre, 2015; Leer, 2016). This can also be translated into the oppression of women in engineering by marginalizing female jobseekers and hindering the upward and vertical career development of female engineers. As Huang and Placier (2015) state, the gender hierarchy in China has never disappeared but changed in form over time, from denying access to schooling and work to implicit and explicit gender norms embedded in daily life experiences. When female engineering students are aware of those patriarchal norms prevailing in this field but feel powerless to change the situation, they might choose to leave this area as a career to avoid the potential risks. Next, I draw on existing research to elaborate how gender norms constrain women's engagement in engineering and STEM around the globe, including in China.

2.3 Gender-related social structures on female engineering students

Social structures regarding gender-STEM norms can possibly reduce women's aspirations and interest in pursuing a career in traditionally gendered disciplines (Gunderson et al., 2012; Riegle-Crumb & Morton, 2017; Lane et al., 2022). Science and engineering fields have long been dominated by white, middle-class men in many countries around the world (Tucker, Hanuscin, & Bearnes 2008; Tonso 2014; Liu, 2020). These fields are always seen as men's field, underpinned by biological determinism and gender essentialism that regards women as inferior, dependent and weaker than men (Starovoytova & Cherotich, 2016).

This section focuses on what existing research contributes to the gender-related patterns associated with women's underrepresentation in STEM fields, particularly engineering. STEM literature is included alongside engineering-specific literature as the four disciplines share similar features and are often studied together. They can help to explain inequalities in engineering from a general perspective. Also, proficiency in science and mathematics is regarded as a prerequisite for excelling in engineering by Smith (2012) and can influence students' decisions to pursue engineering career paths (Godwin et al., 2016).

Studies from around the globe are presented as this is an under-researched area in China. Incorporating an international perspective also provides a broader and more comprehensive understanding of the phenomenon. It highlights the importance of recognizing and appreciating the diverse range of experiences and expressions of gender beyond any single cultural or societal lens. Some literature based on data from Western countries I refer to cannot be unproblematically transferred to Chinese contexts. Highlighting the more nuanced complexities of Chinese women's underrepresentation in engineering is one of the contributions of my research.

2.3.1 Gendered parenting and schooling

Gender norms can be transferred and (re)produced implicitly and explicitly through daily interactions such as parenting and schooling (Beddoes, 2021; van Tuijl & van der Molen, 2016). This gendered mindset often occurs among parents, who can affect their children both consciously and unconsciously (Balakrishnan & Low, 2016; Fouad et al., 2010). In societies like China, adult-child power relations render it particularly relevant that gendered norms are imposed on children through parents exercising their power. Specifically, parents tend to convey explicit messages verbally to direct their young children regarding appropriate gendered performance, and convey implicit messages by acting as role models who are observed and imitated by children (Shawcroft et al., 2023; Xu, 2021).

From the early stages of childhood, parental influence plays an essential role in shaping children’s gendered behaviours. Parents often reinforce gendered expectations through their choices of toys for their children. Globally, daughters are commonly provided with dolls and cooking sets, developing nurturing and emotional literacy, while sons are more likely to receive trucks and building toys, cultivating technical knowledge and skills (Brown & Tam, 2019; Fulcher & Coyle, 2018; Kahlenberg & Hein, 2010). From a post-structuralist perspective, children perform, acquire and internalize their gender subjectivities through playing with toys that are stereotypically associated with a particular gender (Nayak & Kehily, 2006; Francis, 2010). Accordingly, children’s interests start to diverge based on their gender at an early age. In this process, children also actively begin ‘(un)doing gender’ (Butler, 2004), but may get punished for crossing gender boundaries due to the hegemonic power of this monoglossia. They thus perform to meet adult expectations. Furthermore, a US-based study found that girls are more likely to be assigned domestic chores such as cooking, while boys tend to be assigned yard work and house painting (Sweida & Tallman, 2021). The allocation of household chores and toys based on gender can generate an essential association between specific types of occupation and gender roles. This association can potentially undermine girls’ interest in pursuing non-traditional fields for women, such as engineering, a subject dealing with structures and technologies. However, from an intersectional aspect, evidence shows that having a family member working in engineering or possessing a higher level of science capital can improve the possibility of women choosing engineering as both a field of study and a profession (Wang & Degol, 2013; Sundly & Galway, 2021), which will be elaborated on in Chapter 3.

Scholars within the poststructuralist paradigm have suggested that the formation of children's gender subjectivities is inherently fluid and shaped by power relations within educational settings, particularly in the context of school classrooms (Sauntson, 2012). By the time children begin school education, they have already been exposed to familial influences for several years that help shape their expected behaviours and preferences based on gender. This stereotypical mindset can be reinforced and normalized by peer interactions at school, as the power relations among children themselves have the potential to impact their behaviours and attitudes through mechanisms like model similarity and peer networks (Schunk, 1987; Veenstra & Dijkstra, 2011). I regard school peer interactions as part of schooling in this section. Xu (2020) provides a vivid example of how peer interactions at kindergarten actively reproduce gender norms based on his observations in Hong Kong. He witnessed a situation where a boy chose to sit on a pink chair, and his male peers reacted by laughing at him and instructing him to stand up, citing the belief that boys should not sit on pink chairs as they are meant for girls – this is an example of how gender heteroglossia can be punished emotionally. Similarly, children tend to exhibit a preference for peers who conform to gender norms over those who do not act in line with these norms and exhibit gender-nonconforming behaviours (Kwan et al., 2020; Nabbijohn et al., 2020), including Chinese students (Wang et al., 2022). It means that to secure a smoother social experience at school, children may choose to perform and conform to the gender monoglossia.

In addition to peer influences, gendered mindsets toward STEM fields can also be reinforced during their schooling stage through interactions with teachers at school and parents at home. A study in Taiwan showed that male students received stronger family support for their learning of STEM courses in high school than female students (Tzu-Ling, 2019). Western studies also report similar findings. Simon and colleagues (2017) reported that girls received less verbal and material rewards from parents and teachers for equal achievement and curiosity in mathematics and science. Tiedemann (2002) discovered that primary school mathematics teachers often relied on gender norms to explain differences in their students' maths performance. Boys were more likely to be described as possessing the necessary natural developmental resources to excel in mathematics and science (Levine & Pantoja, 2021), as a result of the influence of biological determinism. Monoglossic gender norms can exert pressure on female students through adult-child and teacher-student power relations, leading female students to have lower self-efficacy and interest in STEM fields than males (Guo et al., 2015; Petersen & Hyde, 2017). The disparity between genders in STEM involvement is initiated during the early stages of life and persists throughout adolescence (Charlesworth & Banaji, 2019).

Overall, STEM disciplines are perceived as being excessively competitive, abstract and authoritative, which may make it less appealing to individuals who have been shaped by social structures through parenting and schooling to possess feminine personality traits (Diekman et al., 2015; Simon, Wagner & Killion, 2017). In effect, although the monoglossic gender norms tend to be powerful, a number of female students exercise their agency and actively resist the constructions associated with gender-specific disciplines. However, even for those women who manage to choose an engineering programme at university, they may encounter a 'chilly climate' in the male-dominated environment that prevents them from pursuing an engineering career (Blickenstaff, 2005; Walton et al., 2015).

2.3.2 Engineering programmes at university

Gender norms persist beyond pre-university stages and can be observed within university settings where women take the role of engineering students. They are compelled to navigate male-dominated environments, including classrooms with a higher proportion of male students, men-led leadership groups, male lecturers, and male figures as prototypes or role models depicted in textbooks (Blickenstaff, 2005; Herzig, 2004; Murphy et al., 2018). Male dominance in higher education is globally regarded as a key factor contributing to women's underrepresentation in engineering (Barone & Assirelli, 2020; Lawson, 2021; Reggiani, Gagnon & Lunn, 2024). The overall climate in engineering programmes on campus, defined as the attitudes, perceptions and expectations within an institution (Rodger & Summers, 2008), can be chilly for women, restraining them from achieving their fullest potential (Walton et al., 2015). The 'chilly climate' illustrates how gender monoglossia exercises hegemonic power to punish and marginalize female engineering students as gender heteroglossia. Their gender subjectivities are shaped through repeated interactions within power relations in a predominantly masculine culture. Throughout this process, conflicts, intransigence or compromises can emerge, partially contributing to different career choices of being within or outside engineering. The atmosphere of 'dominant masculinity' in the heterosexual matrix can act as a powerful structure, contributing to women's attrition in engineering in several specific ways.

First, female engineering students tend to lack opportunities to cultivate practical abilities through independent and professional work. For example, male students are more likely to play a dominatant role in engineering lab activities (Tonso, 2007), while women are expected to take on secondary roles, such as taking notes and typing up reports (Riney & Froeschle, 2011; Wieselmann et al., 2020). The restricted access of women to professional roles in engineering labs on campus can have implications for their capabilities in engineering professional practice and competitiveness in meeting the expectations and requirements of prospective employers in engineering. Besides this, psychologically, a lower sense of achievement and self-efficacy (as a reflection of psychological aspects of agency, which will be discussed in Chapter 4) in group work can negatively affect women's engineering persistence in relation to career choices (Jan & Sean, 2012; González-Pérez et al., 2022). Although this negativity is psychological, it comes from their social experiences. Klein (2007) adds that female engineering students often experience apprehension when it comes to operating equipment and machinery during class projects and laboratory practices. This is a result of the fear instilled in them by their teachers and peers, who convey the belief that women lack the capability to handle such tasks, again because of biological determinism (ibid).

Second, the male-dominated environment in engineering does not support the needs of many women who are seeking social connections. Again, this reflects how gender heteroglossia can be punished emotionally. This can also be seen in how woman have limited access to social forms of science capital at university (detailed illustrations of science capital can be found in Chapter 4). In China, most campus activities in science and engineering departments are viewed as men-orientated, resulting in many female students studying at the library or staying in the dorm in their free time, rather than developing various interests or making friends (Wang et al., 2007). After-class isolation may result in the difficulty of being involved in certain study groups required to enhance their academic and practical performances. In addition to undergraduate students, a UK-based study found that a lack of diversity affects the sense of belonging of female STEM PhD students (Reggiani, Gagnon & Lunn, 2024). Belonging is identified by Striolo, Pollock and Godwin (2020) as the most significant factor influencing British women's career choices in engineering. Belonging as a subjectivity relates to how individuals relate themselves to socially constructed institutional relationships. Mahar, Cobigo and Stuart (2013) define sense of belonging by combining five intersecting themes: subjectivity; groundedness to an external referent; reciprocity; dynamism; and self-determination. Applying their definition to the engineering domain, a sense of belonging in engineering/higher education can be a subjective feeling of being respected and accepted, which is derived from a reciprocal relationship to engineering/higher education that is grounded in shared experiences, beliefs or personal characteristics. Lack of belonging claimed by engineering women students can emotionally erode their motivation to persist in the field of engineering (Danielak, Gupta & Elby, 2014; Marra et al., 2012).

In addition, female engineering students commonly perceive fewer opportunities to engage in positive interactions with the faculty due to its bias and discrimination. The US has more research related to faculty's gender bias in STEM. Moss-Racusin and colleagues (2012) suggest that faculties tended to regard female students in science as significantly less competent than male students and that this bias is associated with less support they provide to female students. Additionally, Richard and Susan (2009) note that US female students pursuing engineering and technology courses often face discouragement and off-putting remarks from faculty members. These remarks can include statements such as, 'Women do not become real engineers, why should you waste your time?' Such negative attitudes and biases, rooted in biological determinism, perpetuate gender norms and contribute to a hostile learning environment that undermines aspirations of female students in these fields. In addition to these gender norms, male students in engineering classes often receive preferential treatment and higher expectations by lecturers, consciously or unconsciously, whereas female students tend to be subjected to lower expectations and often feel intimidated (Kombo, 2004). Furthermore, the number of female faculty members in engineering programmes worldwide is poor (AAUW, 2010; National Science Foundation, 2015; Retherford, Mobley & Wyckoff, 2020). Nevertheless, encouragement and support from mentors, especially female ones, are identified by existing research as being important and influential for women's persistence in STEM. This is because they, as same gender role models, can release women's feeling of isolation in a masculine environment and the anxiety of family-work issue traditionally borne by women (Ahn et al., 2019; Balakrishnan & Low, 2016; Christine et al., 2014; Yang & Shen, 2020).

Despite the prevailing view among researchers that the 'chilly climate' negatively impacts female engineering undergraduates, there are a few different voices regarding the impacts of campus on women's persistence in engineering. For example, Marra and colleagues (2012) found in a US-based study that there was no significant difference between female and male students for both academic (curriculum problems and distant faculty relationships) and non-academic factors (lack of belonging), which are commonly regarded as drivers for the low retention rate of engineering students. This finding is based on a survey with only 113 responses in a single university who leave engineering programmes. The sample scale is relatively small, and it neglects a qualitative explanation on why there is no gender difference. A US longitudinal quantitative study carried out by Tenhar and colleagues (2017) also found that perceived engineering career intentions of undergraduate students' remained flat between their first and third years, with no significant gender difference. This is a relatively large-scale study, but the number of participants declined dramatically year on year from 470 to 115, since they were among the initial participants pool and were self-selected to respond to the survey. In this case, students with a stronger intention to pursue an engineering career may be screened out unintentionally. This study also lacks qualitative exploration of why there is no gender difference. Therefore, it is imperative to conduct qualitative or mixed-methods research to better investigate gendered experiences on campus. The present study can contribute to providing more comprehensive insights into this aspect. Elaborate explanations and examples pertaining to this aspect are expounded upon in Chapters 6 and 8.

This section has focused on different social structures of female engineering students as gender heteroglossia within male-dominated engineering programmes at higher education institutions, including the lack of practical opportunities, lack of sense of belonging as well as fewer and more negative interactions with the faculty. There are also studies that argue against the 'chilly climate' and its negative impact on female engineering students, highlighting the necessity for mixed-methods research to investigate the university atmosphere more deeply. There is limited China-based research regarding engineering higher education institutions, so my research can also contribute to filling this gap.

2.3.3 Being an engineer as a career

In the context of my research, which centres around the experiences and career choices of female engineering undergraduates, it is important to illustrate how the experiences encountered along the journey to becoming an engineer can influence their career choices. Even prior to fully entering the workforce, these students are often exposed to biased internship and recruitment processes, which can shape their perceptions and decisions regarding their future careers.

A US study carried out by Seron and colleagues (2016) summarizes female engineering students' internship experiences as being assigned supporting roles or co-workers (assuming) a lack of experience. They state that internships often drive female students to begin to doubt that they will fit into a professional engineering culture. Again, their sense of belonging is diminished due to the 'heterosexual matrix' in their internship experiences. Moreover, difficulties they have faced or failures they encountered during their internship can be interpreted as confirming gender norms suggesting their unsuitability for STEM fields. This reinforces the lower aspirations of some female engineering students even though there are greater possibilities for female than male students to graduate with first or upper second-class degrees in engineering (Jan & Sean, 2012).

With respect to the real workplace, numerous global studies have documented instances of gender bias, unequal opportunities, exclusion and barriers to advancement that women encounter in their pursuit of STEM careers, both within academic settings and in industry (Amon, 2017; Blair-Loy, Pecenco & Cech, 2013; Wynn & Correll, 2017; Xu & Yu, 2013). The workplace climate for engineering women can be no less chilly than university. Regrettably, in many cases, employers have used men's physical strength and the absence of menstruation as their justifications to exclude women jobseekers. They tend to assume that women may find it more difficult to be assigned overtime work or being placed in fields with unfavourable working conditions. This is because the mindset of biological determinism and the influence of gender norms unfairly limit women's opportunities and overlook their abilities. Discrimination against women in the engineering recruitment market forces many Chinese women engineering students to work outside this area or pursue higher academic qualifications in order to compete with men (Guan & Lian, 2016; Xu & Yu, 2011).

Besides this, traditionally in China (and beyond), women bear more domestic obligations while men are breadwinners, thus female students struggle more than their male counterparts with work-life balance while pursuing engineering careers due to their demanding nature (Christine et al., 2014; Male et al., 2018; Si, 2022). This reflects how public patriarchy deprives women's opportunities in engineering careers. Marriage and mothering seem to have larger effects on women than men in terms of careers, at least in the field of engineering. Drawing on survey data between 1993 and 2010 from the US National Science Foundation, it was found that decisions to exit the workforce made by female engineers coincided with the timing of their motherhood (Kahn & Ginther 2015). Furthermore, research by Xu (2015) highlights that demographic factors such as marriage and motherhood have a detrimental impact on the pay levels of STEM women in the US, while no similar adverse effect is observed for their male counterparts. The average income of STEM women across the US is one third lower than their male counterparts, with undergraduate GPA controlled (Xu, 2017). These two findings underscore the existence of gender-based pay disparities in relation to family-related responsibilities under social structures.

Another social structure associated with engineering is the perception or image of this profession, which can affect the narrowing of occupational choices (Gottfredson,1981). As young adults grow up with certain habitus being built, they gradually narrow their scope of acceptable occupation alternatives, by matching their self-images with those of various career options and eliminating incompatible choices (Chan et al., 2019). In this case, misperceptions of engineering during childhood and adolescence may lead youngsters to prematurely reject the domain from their scope of acceptable alternatives (van Tuijl & van der Molen, 2016). In particular, the culture within engineering higher education plays a pivotal role in shaping students' perspectives on the engineering profession (France et al., 2022). There is evidence from the US showing that many students and even some teachers have limited understanding of engineering, perceiving engineers primarily as car mechanics, construction workers or builders working outdoors (Dabbagh & Menasc, 2006; National Academy of Engineers, 2010). Also, evidence from Hong Kong, the US and Australia shows that the public tends to regard engineering as hard, nerdy, masculine and an uncreative application of science (Chan et al., 2019; National Academy of Engineering, 2008; Starovoytova & Cherotich, 2016). However, the president of the National Academy of Engineering, Wulf (2002) states that engineering is about design under constraint, representing an interesting industry that requires creativity and diversity. He emphasizes that if engineers were really dull and nerdy, they would not be considered good engineers and that this industry is in need of more women and minorities to enhance its diversity.

According to studies worldwide, occupational images of the STEM fields are often more static and misunderstood for women (Archer et al., 2012; Chan et al., 2019; Perez-Felkner et al., 2012) and for children from certain ethnic or SES backgrounds (Hughes, 2011). If the surroundings of children provide limited knowledge about engineering and engineers, they may develop occupational stereotypes and misconceptions. Van Tuijl and Van der Molen (2016) argue in a global review that occupational images in STEM seem to be primarily influenced by parents, other significant adults such as teachers, and the media. Well-educated parents and those who work in STEM fields have a more positive attitude towards STEM and their children tend to have a more impartial understanding of STEM (ibid). This can be partly explained by the exposure of science capital, the underlying logic of which will be explored in Chapter 3.

Starovoytova and Cherotich (2016) provide a compelling argument when they highlight a significant challenge arising from the collision of engineering stereotypes and gender norms in Kenya. The engineering stereotype portrays engineering as a profession that is considered ‘difficult’, ‘masculine’ and associated with a ‘noisy and dirty’ work environment. On the other hand, gender norms perceive women as inferior, weak, fragile, highly dependent, and intellectually less capable compared to men. Under these circumstances, women, traditionally encouraged to perform femininity, are more likely to distance themselves from the engineering domain.

2.4 Summary

This chapter began with a comprehensive exploration of the conceptualization of gender. Starting with an outline of Foucault’s poststructuralist theorization of power, I provided an extensive exploration of how other researchers have applied poststructuralism to investigate the dynamics of gender (and briefly touched upon SES and agency). When knowledge becomes so-called ‘truths’, people tend to take for granted the power relations involved (Foucault, 1977; MacNaughton, 2005). Although these so-called ‘truths’ are powerful in shaping individuals’ practices and thoughts, they are fluid and subject to change through the exercise of agency, a key concept to be discussed in Chapter 4. Gender norms can be such ‘truths’ that largely lead to the underrepresentation of women in engineering.

The two extreme conventional gender discourses – biological determinism and gender socializations – were discussed. Both are problematic for ignoring the effects of the other side. Biological determinism is considered an important factor undermining female students’ engagement in engineering, because it links gender with body, suggesting that engineering is inherently not suitable for women. By virtue of Francis’s (2012) theorization of monoglossia and heteroglossia within the realm of gender studies, I noted that female engineering students struggle under the constraints of gender heteroglossia in the traditionally men’s domain. Gender performativity, heterosexual matrix and gender norms were then illustrated. It is important to recognize that gender is neither a fixed nor inherent characteristic, but rather a fluid phenomenon that can be performed and constructed through repetitive behaviours and discourses (Butler, 1990; 1993). The analysis of masculinity and femininity should be approached as separate entities from sexed bodies. Gender norms that people commonly accept are shaped by an underlying invisible matrix of heterosexual power (Butler, 1990). Public patriarchy also illustrates how women are socially assigned greater responsibility for domestic issues, rather than pursuing demanding careers such as engineering or leadership positions.

The abovementioned theories originate from the developed Global North, which may not be unproblematically applied to Chinese contexts due to different social-cultural backgrounds. Nevertheless, as Connell (2014) suggests, innovative work from the Global South usually critically engages with Northern ideas and considers their specific social-cultural contexts. When it comes to China, it is important to integrate Global North theories with Confucianism, which is regarded as the core of Chinese philosophy (Corcoran, 2014; Wang 2021).

The second half of the chapter interpreted the existing literature regarding gender-related social structures affecting female engineering students based on my theoretical considerations. The gender norm that women are not expected to engage with or excel in engineering might be entrenched in parenting, schooling, university and workplaces, influencing women's experiences and career choices in engineering. From a very young age, innocent children are often brought up by parents who are deeply constructed by biological determination and gender essentialism, leading them to treat boys and girls differently. School teachers, peers, and parents collectively tend to perceive boys as more naturally suited for the field of engineering, thus boys are often educated with the explicit goal of preparing them for careers in this domain. Attempting to cross the gender boundaries often results in punishment from the hegemonic power of gender monoglossia in their surroundings (Sauntson, 2012; Fransis, 2012). Girls are thus more likely to perform their gender in a traditionally feminine way. Even if a small number of female students manages to be enrolled on engineering programmes at university, they often experience a 'chilly climate' that, to a large degree, discourages them to persist in this field. Due to a lack of a sense of belonging, limited opportunities to develop practical expertise and more negative interactions with faculty, women as gender heteroglossia may experience an erosion of their engineering subjectivities. Discrimination in recruitment processes and within engineering workplaces, largely generated by public patriarchy and the gender norm that women are not expected to pursue demanding careers, further discourages their pursuit of an engineering career. These longitudinal factors collectively contribute to deterring women from becoming engineers.

Three contributions in my thesis were identified in this chapter. First, while women's underrepresentation in engineering is a popular research topic in the Western countries, it is an under-researched area in China. Existing studies in China regarding this issue mainly focus on pre-university parenting and schooling stages, as well as the biased workplace environment, while higher education is largely neglected. Also, the theory of gender monoglossia and heteroglossia have received very limited attention in gender-related research in China. In addition to this theory, applying Western theories to Chinese contexts and developing China-specific concepts can challenge the intellectual dominance of the Global North. Second, globally, existing research has taken predominantly psychological, quantitative approaches. Gender, SES, and race are often theorized as positivist variables in these studies. There is a lack of mixed-methods investigation into the influence of university experiences on female engineering students. I believe that an explanatory mixed-methods approach can provide more nuanced explanations of the quantitative results, as either numbers or narratives alone may sometimes not fully capture the phenomena under investigation. My PhD research thus focuses on Chinese female undergraduates and employs a sequential explanatory mixed-methods approach. Third, by reviewing literature on women's underrepresentation in engineering, career aspirations in engineering are more often studied. Participants are often university students who have not graduated, and aspirations can shift over time. There is a lack of focus on the final career choice decisions made when female students face the crossroads of graduation. This research thus aims to fill this gap by interviewing newly graduated female engineering students.

While aware of the inability to fully understand and theorize the intricate narratives and interactive forces present within our societal and material realms (Xu, 2018), this research adopts a post-structuralist position, with a shift of focus from materials to discourse, to explore how social structures – particularly gender norms in this chapter – wield the power to contribute to the enduring underrepresentation of women in engineering. To prevent the oversimplification and homogenization of women's experiences and perspectives, the next chapter introduces SES as an intersectional factor, thereby providing a more nuanced picture of how women from different family backgrounds negotiate the social structures found in engineering.

Chapter 3 Integrating socioeconomic status into engineering settings

This chapter adopts the perspective of intersectionality, integrating SES with gender in order to investigate the experiences and career choices of female engineering students. Following a similar pattern in Chapter 2, this chapter starts with my understanding and theorization of SES in general. I draw on concepts of capital, habitus and field developed by Pierre Bourdieu, whose theoretical framework is frequently linked to a synthesis of sociological perspectives. In particular, from a post-structuralist perspective, I attempt to theorize SES as being negotiated, fluid, dynamic and interconnected in discourse practices (Allard, 2006). Subsequently, science capital coined by Louise Archer and her colleagues will be introduced as an aspect of SES specifically in the domain of engineering. It constitutes the core concept underpinning my research on female engineering undergraduates in China. I then incorporate an intersectional perspective to theorize gender and SES. Based on my theoretical understandings, the last section reviews existing empirical studies concerning the influences of SES and gender in engineering experiences and career choices.

3.1 Post-structuralist understanding of SES

My understanding of SES from a post-structural perspective is developed from Pierre Bourdieu (1977, 1984, 1986, 1987), though his theoretical stance can be characterized as a combination of various perspectives. He extended the Marxist understanding of class from only a material aspect to consider the significance of economic, cultural, social and symbolic forms of capital. He defined capital as resources in a society that can bring people social advantages within particular fields. Economic capital simply refers to monetary wealth. Cultural capital can be understood as wealth in the form of ways of thinking and being. In Bourdieu's (1977: 243) words, it refers to 'linguistic and cultural competence and the familiarity with culture'. There are three primary categories of cultural capital: ownership of objectified cultural items like books and artefacts; the internalized long-term disposition and state of a person; and institutional cultural capital such as academic qualifications obtained through formal education. Social capital thus refers to the social networks to which people belong. Symbolic capital is about the legitimacy that certain types of capital taked on, and how those capitals are weighted in relation to each other. These four forms of capital do not operate independently; rather, they are usually interrelated, meaning that individuals affiliated with higher capital of certain form tend to possess enhanced opportunities to access to other forms of capital; and they interact to shape an individual's position within a specific field (Bourdieu, 1986).

Bourdieu's emphasis on the roles of symbolic and cultural capital can be interpreted in a post-structuralist framework, though he is often regarded as a structuralist, because they highlight the importance of discursive practices and the construction of meaning. Post-structuralism emphasizes that power, embedded in discourses and practices of communication, constructs and deconstructs possible meanings in various social contexts (Crick, 2016). Both symbolic and cultural capital often have fluid meanings across fields, and they often do not operate uniformly across all contexts. Social capital can also manifest through language and discursive exchange during interpersonal communications. Therefore, in my view, SES is not just about material conditions but can be a discourse about what and who is valuable and respectable in society (Holmes, 2007), such as how SES affects individuals' perspectives and choices regarding learning engineering at university and being an engineer. Children from families with less cultural and social capital often have narrower access to quality education, fewer role models and social networks, and less knowledge of vocational trajectories (van Tuijl & van der Molen, 2016). Individuals from disadvantaged SES backgrounds often encounter various restricted opportunities in different fields.

Different fields may value different types of capital, which at the same time are mutually related. A field, according to Bourdieu (1977), is a series of structured power relations between individuals. Fields govern the rules of games which determine the value of particular capital (Archer et al., 2015). Bourdieu's concept of 'field' can also be seen as aligning with post-structuralist ideas, as it recognizes that different social spaces are characterized by power dynamics in the struggle for dominance. Thus, the structures of fields can be interchangeable and fluid. For example, my findings suggest that possession of cultural and social forms of capital related to engineering have a more noticeable impact on students' experiences and career choices in the 'field' of engineering. However, those capitals related to engineering would become less valuable in the 'field' of social science.

Bourdieu (1986) proposed that patterns of social difference can be produced and reproduced through the interplay of capital, habitus and field. Habitus is the series of obtained and consistent ways of doing and thinking which are long-lasting but not permanent (Bourdieu, 2002). His conceptualization of habitus, in particular, reflects a structuralist perspective, as it highlights how individuals internalize social structures and norms, leading to the reproduction of social hierarchies. Reay (2004) argues that habitus can thus primarily serve as a tool to analyse how subordinate groups in society consistently come to be dominated and how the dominant groups reproduce their power.

In addition to class, which is more frequently emphasized by Bourdieu, gender is also a factor in the social hierarchies that can be analysed by habitus (McClelland, 1990). Bourdieu (2001) proposes 'gendered habitus', which is mainly associated with the gendered division of labour between men and women. In patriarchal societies, men are more likely to be encouraged to develop the type of habitus that can reinforce their dominant position in society, while women tend to be encouraged to be submissive and subordinate to men. In monoglossic gender structures, individuals perform their gender and acquire gendered habitus following repetitive and stylized social behaviours and language. Therefore, female engineering students often face struggles when engaging with engineering study at university, as they tend to develop a gendered habitus, through gender performativity, that conflicts with the male-dominance in engineering. Reay (1995) also suggests that gendered habitus can be mediated by social class, which is associated with my application of intersectionality in this study (see Section 3.3).

In the discourse surrounding habitus, acknowledgement of agency (see Chapter 4) is not entirely negated; however, Bourdieu asserts that components of the self, including beliefs, values, language and dress, are strongly shaped and influenced by social structures such as class, gender and ethnicity (Bourdieu, Passeron & Nice, 1977). In other words, it tends to emphasize the reproduction of existing social structures rather than transformative potential (Akrivou & Di San Giorgio, 2014). Bourdieu is often regarded as a structuralist because many scholars contend that he leaves no room for agency (Dowding, 2008). According to a critique by Crossley (2001), Bourdieu lacks a theoretical framework that establishes a connection between embodied dispositions and individual cognitive processes, reflective thinking and agency. Nevertheless, Bourdieu suggests that agency can only be experienced through practice or habitus, even though it cannot be directly observed (Dowding, 2008). In my perspective, habitus influences and situates agency, as individuals' dispositions and socialized behaviours shape their perceptions and choices. Through critical reflections, conscious choices, and exposure to alternative social contexts, individuals can agentically reconfigure their habitus and enact changes in their behaviours and social positions. The notion of habitus as a stable, deeply internalized set of dispositions may oversimplify the ways in which individuals actively engage with and adapt to their social environments. The limitations can be complemented by considering the theorization of gender in the previous chapter. I regard gendered habitus as a social structure that can be subverted by individuals' gender performativity and the agentic negotiation of gendered power. The narratives and stories of female engineering students in my study are analysed on the premise of agency and through the possibilities of transformation, along with reproduction. Female students' engineering subjectivities can become stable when habitually accessed by themselves and recognized by others over time and can also be subverted due to changes in sociocultural environments. Individuals with various habitus and capitals contend in different fields, indicating the dynamic feature of structure. I regard field, as well as habitus and capital that play within the field, as social structures, imposing impacts on people's agency. At the same time, individuals actively engage in the ongoing processes of reproducing or challenging social class, while acquiring various forms of capital by exercising their agency in different ways.

Due to different volumes of capital held by different individuals, structures can be hierarchical. As mentioned in Chapter 2, post-structuralism highlights the role of power in shaping social hierarchies. SES is thus not simply an economic or material condition but a site of power relations. Those in higher SES positions have more access to resources, opportunities, and social privileges, while those in lower SES positions are marginalized and face systemic barriers. Through the interaction of capital and habitus within the field, families with greater resources are more likely to cultivate dispositions and behaviours in children that resonate with the field of education (Bodovski, 2014). This, in turn, leads to better academic attainment and higher aspirations for post-compulsory educational participation (Israel, Beaulieu & Hartless, 2001; Martin, 2009; Zhao et al., 2023). This means that obtaining more capital is a reflection of power, which grants individuals the privilege to preserve and reproduce their existing advantages. Moreover, a high level of capital usually comes with privilege and high affordances, providing individuals with the power to challenge existing social structures. They may feel more confident in 'testing the water' to see what happens if they do not conform to norms. From an intersectional perspective, women with higher levels of capital related to engineering can be better empowered to challenge gender norms and engage with engineering.

Overall, SES is not an inherent or objective characteristic but a product of social constructions and relational systems of meaning and power. It is generated through discursive practices that assign value and meaning to different positions within the socioeconomic hierarchy. Besides this, individuals occupy multiple subject positions within the socioeconomic order. Their experiences and subjectivities can be influenced by the intersections of various social categories such as gender, religion, race, and ethnicity. SES intersects with other forms of oppression and privilege, creating complex and fluid subjectivities. This research holds that gender and SES actively interact with different forms of capitals to reproduce or subvert existing habitus. Since most Chinese students are Asian and among Han nationality, and hold no religious beliefs, it is not the intention of this study to explore demographic intersections beyond gender and SES. Section 3.3 will provide more details from an intersectional perspective.

It is worth noting that Bourdieu's theories are also set within the contexts of the Global North, similar to the gender theories discussed in the previous chapter. Nevertheless, Bourdieu's sociology has received much attention from education researchers in China (Shi & Li, 2018). Various adaptations of his concepts have been explored in Chinese literature, such as the 'cultural capital of underclass' promoting rural students in China to attend elite universities (Cheng & Kang, 2016), and the classroom field contributing to Chinese students' silence (Wang & Ma, 2020). Thus, China can provide a valuable and robust context for Bourdieusian studies. However, Mu, Dooley and Luke (2019) suggest that applying Bourdieu to Chinese educational research should be more critical and reflexive. Liu (2014) also criticizes that during the period of social change in China, the application of Bourdieu in Chinese contexts has been somewhat selective, with a stronger emphasis on political and economic factors than on education itself. Therefore, in applying Bourdieu's concepts to Chinese contexts, this study will maintain a strong educational focus, and will be both reflexive and critical of the specific socio-cultural dynamics in China.

A substantial body of scholarship has emerged to expand and refine the conceptualizations of capital, encompassing both advancements within the Bourdieusian framework and extending beyond its boundaries. These endeavours include, but are not limited to, emotional capital (Reay, 2000); linguistic capital, which pertains to language skills and proficiency (Stanton-Salazar & Dornbusch, 1995); identity capital, as conceptualized within social psychology (Côté, 2002); and economics-based conceptualizations of human capital (Becker, 1993). More recently, the concept of 'science capital' has been coined by Louise Archer and her colleagues, which can be a valuable theoretical framework for studies in STEM fields.

3.2 Science capital

'Science capital' (see Archer et al., 2012; Archer et al., 2015; DeWitt et al., 2016; Moote et al., 2019a; Moote et al., 2019b) is a core concept guiding my research to explore how SES intersects with gender to affect engineering career choices. It is derived from Bourdieusian sociological theory of capital. Bourdieu conceptualized his theory primarily in the context of the arts. For instance, he measured cultural capital based on the art taste and consumption of beaux arts, such as the opera and classical music concerts (Bennett et al., 2009). In Bourdieu's later work (2005), he acknowledged the presence of 'technical' capital, although it can be argued that these ideas were not extensively elaborated upon or integrated into his conceptualization of cultural capital, which primarily focused on the arts. Archer and colleagues (2015) extended his work to recognize the value of science-related forms of habitus and capital, with evidence drawn from UK contexts.

'Science capital' refers to science-related forms of habitus, cultural capital and social resources (Archer et al., 2015). Specifically, the theoretical model of science capital combines 'scientific forms of cultural capital (e.g., scientific literacy; science dispositions, symbolic forms of knowledge about the transferability of science qualifications), science-related behaviours and practices (e.g., science media consumption; visiting informal science learning environments, such as science museums), science-related forms of social capital (e.g., parental scientific knowledge; talking to others about science)' (Archer et al., 2015: 929). Archer, Dewitt and Willis (2014) posit that 'science capital' should not be regarded as an independent category of capital, but rather as a conceptual tool that brings together diverse forms of capital that are specifically relevant to the domain of science. It emphasizes the potential of these capital types to generate value for individuals or groups, enabling them to bolster their achievements, involvement, and participation in the field of science.

Archer and colleagues' 'science capital index' was created to methodologically measure the volume of science capital that one holds, containing 14 items/questions that are most closely related to a dependent measure of future science affinity and science identity (Archer et al., 2015; DeWitt et al., 2016; Moote et al., 2020). These include dispositional items, behavioural items, social capital items and science knowledge, corresponding to the above-mentioned dimensions of science capital. In the survey for the present study, this index was adapted, through a cognitive interview strategy, to ensure its alignment with the specific contexts of my research. Engineering elements and Chinese contexts were considered and added to the index after consulting scholars in Archer's team. A comprehensive account of the adapted version is presented in Chapter 5. Appendix-II shows a detailed summary of the science capital index and the adapted version.

Existing empirical research suggests that the acquisition of a higher level of science capital supports the cultivation of scientific aspirations among students. Specifically, the amount of science capital UK students (10-18 years old) have access to is positively associated with their decision to pursue a science-related subject in post-18 study (Moote et al., 2019a). In the ASPIRES study, which examined the science and career aspirations of children aged 10 to 14 in the UK, it was observed that children from families with greater access to science-related resources demonstrated a higher aspiration to science-related careers and to pursue science studies beyond the age of 16 (Archer et al., 2012; Archer, Dewitt & Willis, 2014).

According to Archer and colleagues (2015), science capital is unevenly distributed across the population: 5% of surveyed UK students were categorized as having 'high' science capital and 27% with 'low' science capital; this is largely mediated by gender, class and ethnicity – students from socially privileged communities, such as white men with higher levels of cultural capital, are often more exposed to science capital. Families with higher levels of science capital are more likely to encourage and promote their children's science exposure (Archer et al., 2015). It seems that family and media make bigger differences to young students' science capital, but school science fails to provide young students with the most valuable forms of cultural and social capital (Archer et al., 2015; Claussen & Osborne, 2013). This is in line with Holman's (2007) argument that within school, engineering courses seem to play a very limited role in the development of engineering capital due to the rare engineering opportunities within formal curricula and limited perceptions of engineering by teachers. A lack of prior university engineering experience can more severely aggravate the difficulties of choosing an engineering career than science, maths and technology disciplines (Williams, Engerman & Fleming, 2006; Marra et al., 2009).

More recently, Moote and colleagues (2020) have tried to test, in a quantitative way, whether science capital can be extended and applied to STEM in the UK. They found that students' post-compulsory study aspirations of engineering and physical science are strongly related to science capital while the relationship with maths and technology is much weaker (mainly associated with attitudes, not aspiration). They offer a speculative explanation that both physical science and engineering are commonly regarded as related to the physical world, while mathematics and technology are more associated with the digital world. This study implies the potential applicability of science capital within the context of engineering disciplines. However, it is important to acknowledge the limitations inherent in this singular study, as further research is needed to establish a more comprehensive understanding of the relationship between science capital and engineering field. Additionally, they found that science capital is less strongly correlated with engineering attitudes than with science attitudes. This indicates the necessity to investigate capital that is more specifically focused on engineering. Cannaerts and colleagues (2023) attempted to adopt 'engineering capital' as a manifestation of 'science capital' in the engineering field in Belgium. However, their research mainly transfers ‘science’ related aspects into ‘engineering’, while my study contributes to providing a more comprehensive and culturally sensitive methodological and theoretical reconceptualization of ‘engineering capital’ in engineering disciplines and Chinese higher education contexts (see Chapter 10 for further discussion).

The primary difference between my research and that of Archer and colleagues’ resides in the demographic composition of the survey participants. Specifically, my study focuses on Chinese university students, while science capital-related studies predominantly encompass pre-university students from the UK. Drawing on their findings, it can be assumed that among university students, those pursuing engineering disciplines tend to possess a higher level of science capital in contrast to students studying other subjects, particularly those in the realm of arts and social science. Consequently, it appears that my study lacks a basis for direct comparison with Archer and colleagues’ results. Nevertheless, I consider science capital to be a valuable theoretical framework that can furnish valuable insights and guidance for my research endeavours, as it incorporates the intersectional lens of gender and SES in the field of STEM. I view science capital as one form of expressing SES, which has implications for individuals’ agency. If women have access to a higher level of science capital, they could be more agentic in reacting against social constraints brought about by gender norms. Science capital can also be a social structure subject in different contexts. To challenge the dominance of theories from the Global North, one of the aims of my research is to investigate the reconceptualization of ‘science capital’ into ‘engineering capital’, particularly regarding Chinese female engineering undergraduate students from different SES backgrounds.

3.3 Intersectionality of gender and SES

Increasing attention to intersectionality has been announced by sociologists to examine how various social categories intersect to generate systemic forms of inequality. In line with my post-structuralist position, intersectionality indicates anti-essential conceptualizations of subjectivities and emphasizes the fluidity of power relations. Crenshaw (1989) first articulated the intersectionality framework to illustrate how gender and race interact to shape the particular experiences of Black women in the job market, as investigating gender or race separately cannot fully capture their experiences. The underlying purpose of intersectionality is to critique the privilege of normative identities, which are typically associated with white, Western, cisgender, middle-class, heterosexual men as the standard (Wyatt, Johnson & Zaidi, 2022). By examining intersecting social subjectivities, intersectionality seeks to uncover how systems of power and oppression interact and compound, shaping individuals' experiences and opportunities within society. Linking back to Foucault's conceptualization of knowledge and power (see Chapter 2), according to Collins (2015), intersectionality can be understood as a comprehensive endeavour to understand and address the complex social inequalities existing within power relations. This is achieved by encompassing various knowledge projects that evolve in response to the ever-changing dynamics of social formations, and that mutually influence each another (Collins, 2015).

Collins (1991) and McCall (2005) apply intersectionality to all women by claiming that gender is always interrelated with other cultural structures of 'oppression'. Women are differentiated as individuals based on class, ethnicity, age, religion and other characteristics. For example, the needs of young single women in a metropolis may be different to the interests of elderly lesbian couples in rural areas. There are hierarchies of oppression among different subgroups of women. In contemporary societal structures, individuals who identify as white, heterosexual women from a middle-class background tend to occupy a relatively privileged position within the social hierarchy (Wyatt, Johnson & Zaidi, 2022). In contrast, Black lesbian women who belong to the working class are more likely to find themselves positioned at the lower end of this hierarchy. This means that women are not equally disadvantaged but share a social subjectivity as 'women' is largely applied to understand gender inequalities.

Developing Bourdieu's ideas, Skeggs (1997) highlights the significance of class in the symbolic construction of gender by claiming that the forms of capital profiled can be organized and valued within the social interrelation of gender and class. Reay (2004) also asserts that people from working-class backgrounds continue to have limited opportunities partly attributed to the way ideas about class and gender affect their capability to effectively make use of any chances available for themselves or their offspring. This echoes issues mentioned in Section 3.1, in that habitus can be co-shaped by gender and SES. Reay (1998; 2004) consistently asserts the necessity of a broader examination of the ways in which class is manifested and experienced through gendered discourses. In STEM fields, several studies emphasize the importance of analysing the factors that contribute to STEM participation by considering the intersection of various social statuses (Perry et al., 2012; Ong, 2023; Reggiani, Gagnon & Lunn, 2024). This is because intersectionality enables the identification of differential vulnerabilities and the underlying mechanisms that give rise to inequalities within different subgroups, for example female engineering students. It also has the potential to inform the development of more focused and tailored STEM educational policies and practices. By recognizing and addressing the unique challenges faced by individuals at the intersection of multiple social subjectivities, inclusivity and equality in STEM education and the workplace can be promoted more effectively.

At the end of this section, I summarize how intersectionality is used in this PhD research. The current discourse surrounding intersectional research, as highlighted by Collins (2015), involves a debate about its precise definition and scope. While the concept of intersectionality has gained recognition in various disciplines, it is acknowledged that there is a limited amount of guidance available to researchers on how to effectively conduct intersectional research (Bowleg, 2008; Bowleg et al., 2003). In the attempt to apply intersectionality in my study, it is approached and utilized both as a theory and an analytical tool (Buchanan & Wiklund, 2021).

As a theory, it reminds us that understanding Chinese female engineering students' lives and experiences cannot be achieved by solely considering a single subjectivity category, because they are shaped by a multitude of intersecting factors and social dynamics. It helps to understand the complexity, dynamics, and discursiveness of the gendered and SES-related social structures. It provides a theoretical understanding of how gender and SES can intersect to impact female engineering students' experiences and career choices.

As an analytical framework, it assists in identifying and analysing the ways in which different forms of privileges and marginalization intersect to produce unique experiences and choices. My analysis follows a more nuanced form of intersectionality, considering both micro-level intersections and the 'upstream' toward broader social structures of power and privilege (Moradi & Grzanka, 2017; Wyatt, Johnson & Zaidi, 2022). Gopaldas (2013) clarifies that, from a micro perspective, intersectionality implies that every individual within society occupies multiple positions within these social subjectivity structures, leading to the presence of multiple social privilege and oppression; at a macro level, it encompasses the interplay among social identity structures such as class, gender and race, which collectively shape individuals' lived experiences, again particularly in terms of advantages and disadvantages. Connell and Pearse (2015) also suggest that intersectionality researchers emphasize the interplay between two expression forms of social structures, including how they change each other, and how particular social situations are created by mutual effects. Therefore, my intersectional analysis aims to explore how social and institutional constructions related to gender and SES shape female engineering students' subjectivities, lived experiences, and career choices of being inside or outside engineering, as well as how the two elements co-shape the effects of the other.

3.4 SES-related social structures on engineering engagement and the intersectionality with gender

Family SES is emphasized in existing literature as a potential factor affecting students' STEM subject and career choices. Parents who act as guides and role models can influence students' STEM aspirations through constant verbal communication and behavioural demonstration (Balakrishnan & Low, 2016; Fouad et al., 2010). This influence can operate through the lens of habitus, capital and field, which were discussed in Section 3.1. In particular, science and engineering-related capital can provide advantages in STEM fields. As individuals possess different types and volumes of capital, and travel across different fields, their habitus can be fluid and changeable. The habitus favoured within STEM fields can undergo processes of reproduction or subversion in response to environmental shifts. In the process of capital, habitus and fields interacting with each other, individuals exercise their agency in different ways to make subject and career decisions. More importantly, as noted in Section 3.1, habitus is affected not only by capital, but also by gender. This resonates with the theory of intersectionality. An intersectional lens that unites SES, as discussed in this chapter, and gender, discussed in the previous chapter, can provide a fuller understanding of women's engagement in engineering. Based on these theoretical considerations, this section interprets existing empirical evidence on how SES alone influences engineering aspirations and how SES intersects with gender to co-shape engineering engagement.

As in Chapter 2, in this section, I review both STEM and engineering-specific literature due to their shared characteristics and frequent co-research. By considering these disciplines collectively, I can gain a broader perspective that sheds light on the underlying causes of inequities in engineering from a general standpoint. Upon reviewing existing global literature, it becomes evident that there are divergent perspectives regarding the implications of SES intersecting with gender on students' aspirations in STEM disciplines. Those insights highlight the multifaceted and complex interplay between SES, gender, as well as STEM subject and career choices in different social cultural contexts.

3.4.1 Beginning with socioeconomic status alone

Most existing global studies uphold that students with higher-SES parents are more likely to choose STEM subjects and careers (see Archer et al., 2017; Carrico, Murzi & Matusovich, 2016; Codiroli, 2015; Wang & Degol, 2013; Sundly & Galway, 2021). Students from higher-SES families tend to have more exposure to science capital, as illustrated in Section 3.2. Lack of social and cultural capital in the field of STEM can become an obstacle, hindering the formation of STEM habitus. These obstacles encompass various aspects, such as limited support from peers and parents in pursuing STEM fields and fewer opportunities within their educational institutions to cultivate STEM-related skills (Alliman-Brissett & Turner, 2010; Carrico, Murzi & Matusovich, 2016; Wang & Degol, 2013; Turner et al., 2019). The visitor profile for science museums and informal science activities (science-related cultural capital) tends to be overwhelmingly middle-class among OECD countries (OECD, 2012; Keith & Griffiths, 2021). Associated with science-related social capital, it is argued that parents' occupation can also be an important factor. Having an engineer in the immediate family as a role model has a significant positive impact on the students' knowledge and habitus in engineering and thus promote their interests in pursuing engineering as a career; and a female role model in the family exerts even greater influence for the female students (Anderson & Gilbride, 2007; Madara & Cherotich, 2016; González-Pérez, Mateos de Cabo & Sáinz, 2020).

When it comes to economic capital, existing literature seems convey a message that no matter whether families have a lower or higher level of economic capital, they all have reasons to choose STEM subjects, which are usually associated with high salary potential. From the perspective of social mobility, individuals tend to strive for a social position that is at least equal to or better than that of their parents, primarily motivated by the desire to avoid downward social mobility (Breen & Yaish, 2006). On the one hand, it resonates with the results of a UK-based study carried out by Davies and colleagues (2013), which found that students from higher SES backgrounds are more likely to consider financial returns when making subject choices, including STEM disciplines, to maintain their social standing. In line with this interpretation, students from working-class backgrounds or those with parents with limited qualifications may perceive studying any subject at higher education institutions as a means of upward social mobility. On the other hand, it also makes sense that students from more financially disadvantaged backgrounds often prioritize the perceived financial returns associated with their choice of subjects, such as engineering subjects, which are usually associated with high salary potential. For example, a UK-based study (Mcmaster, 2017) and a US-based study (Johnson & Muse, 2017) suggested that students from lower SES groups may face more risks and be more reluctant to opt for arts and humanities subjects. As Ma (2009) demonstrates, in a US sample, lower SES students are more likely to pursue technical, health science and business majors that can offer higher potential for economic and social advancement to mitigate the risks associated with their disadvantaged backgrounds. Therefore, the two contradictory perspectives indicate that compared with science-related social and cultural capital, economic capital may have more limited implications on engineering habitus and aspirations for students from different levels of SES backgrounds. This also resonates with my previous statement in Section 3.1 that different fields may value different types of capital.

In addition, specific STEM fields (Bourdieu, 1984) each have their own features. Van Tuijl and van der Molen (2016) hold that students from disadvantaged family backgrounds are less likely to learn STEM and pursue a STEM career because these fields are normally regarded as ‘difficult’ or ‘tough’. A UK-based study found that most parents often perceive themselves as being incompetent to provide effective STEM education to their children at home (Cardoso & Solomon, 2002), let alone parents who lack cultural capital. This more severe perception of incompetence from lower SES parents can result in reduced parental involvement in their children's STEM learning, making it more difficult for their children to cultivate STEM-related habitus (Solomon, 2003). It is worth noting that a small number of Western studies conclude that SES seems to have no influence on career aspirations (Deniz et al., 2014; Lent, 2005; Patton & McMahon, 2006). This may be because of the proximal family environment, such as parental attitudes and beliefs, in mediating the negative influence of lower SES on aspirations and career decision-making processes (Bandura et al., 2001; Gutman & Schoon, 2012; Perera, 2014).

When it comes to university as a new 'field' (Bourdieu, 1984), from a macro sociological perspective, researchers commonly perceive universities as institutions that perpetuate class inequality. In the US, the higher education system is seen as a mechanism through which the elite, particularly white individuals from privileged SES backgrounds, secure and reinforce institutional, cultural and economic power (Pawley, 2019). Similarly, a Bangladesh-based study concluded that SES has positive influences on students' academic and professional achievements in engineering programmes at university (Alam & Forhad, 2022). In Mexico, tertiary education in engineering has been implicated in the reproduction of both class and gender inequalities due to the embedded male-dominant and middle-class culture (Bustos, 2008; Buquet-Corleto, 2011). Consequently, students from lower SES backgrounds may encounter difficulties in navigating the environment of higher education (Reay, Crozier & Clayton, 2009, 2010). These institutionalised norms and power relations are thus more likely to pose challenges to engineering students from lower SES backgrounds and influence their decisions regarding career pathways. Finally, based on my theorization of SES, I contend that the disparity resulting from differences in familial background cannot be readily bridged through the mere provision of additional opportunities for institutional scholarships, as asserted by George-Jackson (2014). This is because habitus, though not fixed, is difficult to change (Bourdieu, 2002). Monetary assistance alone cannot compensate for the intangible impact on habitus of family cultural and social capital. A study in China also argued that although university students from lower SES backgrounds distance themselves spatially from their rural origins, the long-term rural experiences remain internalized in their logic of action during the process of subjectivity reconstruction (Zhu & Cao, 2021). That is the class-based habitus.

This section began with the influences of family-based science capital, cultural capital and economic capital on cultivating a habitus conductive to engineering and STEM. University, as a field that reinforces class inequality has been contextualizing for this research, which targets university students. The intersectional influence of gender and SES in engineering departments at universities, mentioned briefly above, is explored in more detail in the next section.

3.4.2 Intersecting socioeconomic status and gender

Building upon the examination of SES-related factors and mechanisms that manipulate engineering aspirations, this section elaborates the intersectionality of SES and gender to present a more intricate and comprehensive demonstration. Habitus is not only classed – it can also be gendered (Bourdieu, 2001). Existing global research on this topic presents two distinct arguments regarding the intersectionality of gender and SES in shaping students' experiences and career choices in engineering. Most researchers advocate that women from lower SES backgrounds experience more potential obstacles in their experiences and career choices in STEM, while a small number of studies conducted in super wealthy countries hold that women from lower-SES backgrounds tend to have higher engineering aspirations than those from higher-SES backgrounds. These inconsistent results on how gender and SES intersect among existing literature enhances the importance of my research in Chinese contexts to adopt intersectionality lens.

Helbig and Leuze's (2012) German study found that women belonging to higher social classes exhibit greater interest in pursuing occupations traditionally associated with men, which is attributed to a well-informed understanding of career options and the influence of their parents' fluid views on gender roles. That is how social capital and cultural capital can develop the habitus associated with their class/SES. Children from higher SES backgrounds are more likely to pursue science not merely because their families encourage strong science interests and orientations, but also because they receive substantial and persistent support from middle-class families (Archer et al., 2012). Additionally, studies in China, African and Western countries claim that gender norms in subject and career choices tend to be less prominent in high SES families (Hailu, 2022; Liu, 2020; Novakovic & Fouad, 2013). This echoes Section 3.1, which observed that a high level of capital can empower individuals to resist monoglossic norms, with less concern about possible punishment.

The existing literature further indicates that social factors may exert stronger influences on STEM women, and they often require additional support and encouragement from family members to persist in their STEM aspirations and career development (Hazari, Tai & Sadler, 2007; Taasoobshirazi & Carr, 2008; Xu, 2017). Intersecting this phenomenon with SES, Codiroli (2015) claims that UK students with parents who have attained higher levels of education are more likely to choose STEM subjects and careers, and this relation is more pronounced for female than male pupils. In China, Yang and colleagues (2017) showed that parents' SES was higher among female engineering students than among their male counterparts. Considering the challenges posed by gender norms that place women at a disadvantage in the field of engineering, it can be argued that individuals from higher SES backgrounds may offer a compensatory advantage. Together with gendered examples described in Chapter 2, this suggests that the women from lower SES families are less likely to pursue and persist in their pursuit of an engineering career.

However, in some circumstances, women from higher SES backgrounds are less inclined to pursue engineering. This is understandable because structures are fluid and contextual, within which agency and engineering subjectivities can be shaped by gender and SES in varied ways. For example, a study in United Arab Emirates (UAE) by Aswad, Vidican and

Samulewicz (2011) suggested that the primary earnings of affluent citizens from the oil industry rely on their connections with political elites and ruling families, so female students from affluent families can easily secure high-placed jobs using their parents' social resources. In other words, women from higher SES backgrounds in UAE do not need to pursue engineering unless they are passionate about it, while lower-SES students are in greater need of a strong engineering academic background to secure job positions. Some US-based intersectional research also indicates that the gender gaps in STEM aspirations, attitudes, and performance are greater among students from more privileged families (Charles et al., 2014; Ma, 2009; Penner & Paret, 2008). This means that female students from higher SES families may sometimes be the group with the lowest STEM aspirations. It is noted that both UAE and the US are very wealthy countries, where the SES structures could be different from other nations. Female students from higher-SES families in super rich countries can more easily maintain their privilege with the help of their elder generation, so that they are less pressured to pursue lucrative STEM careers, while students from lower SES background are more likely to choose lucrative majors (Charles & Bradley, 2009; Ma, 2009). This is in opposition to the perspectives of social mobility that empowers higher SES students a higher motivation to pursue a high-paid job (see Section 3.4.1). In this context, women from higher SES families often possess greater freedom of choice in their career decisions, as they are not constrained by significant financial considerations. SES structures can thus also be theorized as contextual. In this case, it is necessary to investigate the Chinese contexts to see how SES structures look and how they intersect with the gendered structures.

There is very limited research about gender and SES in terms of female engineering students' career pathways in China but based on this, the Chinese situation is more likely to be in line with the former argument. For example, according to a survey carried out at a Taiwan university (Ling, 2017), up to 76.2% of science and engineering students are from high- and middle-SES families. Liu's (2020) study identifies two mechanisms behind the gender and SES implications on STEM career aspirations in China: instrumentalism and (de)stereotyping. Instrumentalism refers to the instrumental calculation of economic returns and material security in developing career aspirations. (De)stereotyping considers how family privileges are associated with gender (de)stereotypes. These two mechanisms reflect the intersectionality of SES and gender. Liu’s (2020) finding shows that female students from more privileged families tend to have higher self-expressive value and a lower instrumental motivation to learn maths, but they tend to have a less gender stereotyping mindset. The two mechanisms can work in different directions at individual level, and the influence of family privileges on gender differences in STEM depends on the tension between them. In this process, agency is exercised based on the battle of the two mechanisms that are constructed by the interaction of habitus and capital in the field of maths. A detailed theorization of agency will be provided in Chapter 4. Liu (2020) argues that family privileges tend to help cultivate Chinese students’ STEM aspirations rather than discourage them. China is a less developed society where educational resources are unevenly distributed, so higher-SES parents provide their children with better educational resources and encourage their children to learn STEM subjects to reproduce the privilege in such a society. This again reflects the contextual differences from super rich countries. Liu’s findings are in line with the survey results of three recent studies in China (Du, Zhao & Wang, 2018; Li, Zhu & Pan, 2020; Luo et al., 2024), which conclude that students from families with high SES tend to have greater STEM career aspirations due to possessing high science capital; in contrast, the STEM career aspirations of students with middle and low levels of science capital are mainly driven by self-choice rather than family influence, because their disadvantaged families cannot provide them with the necessary support. Most existing Chinese studies on this issue have adopted quantitative approaches, lacking qualitative investigations into contextual influences. Therefore, my study can contribute to filling this gap by conducting mixed-methods research.

External social influences, such as gender and SES inequalities, can be internalized as mental schemata by female engineering students, creating a ‘socialized subjectivity’ (Bourdieu & Wacquant, 1992). Agency theory (Chapter 4) helps to capture how they navigate, reframe, and act during the career decision-making process. Although they are active agents, their absorption of this mental schemata can impact their alternatives in terms of career development (van Tuijl & van der Molen, 2016). Overall, the existing literature presents contrasting opinions and debates regarding how SES either fosters or hinders the engineering aspirations of female students. This can be a result of the fluid and contextual nature of SES structures. This divergence of perspectives adds an intriguing dimension to further investigation into Chinese contexts.

3.5 Summary

SES is understood in this chapter as being negotiated, fluid, dynamic and interconnected in discourse practices. The discursive meanings possessed by different SES cohorts can be influenced by their beliefs and values. Gaining an understanding of these meanings can provide insights into how individuals interpret and understand their social positions, as well as the power relations and social hierarchies present in society. My conceptualization of SES related to female engineering students mainly draws upon established sociological theories from Pierre Bourdieu and Louise Archer. It includes economic, cultural and social forms of capital, in particular those related to science and engineering.

I attempt to interpret Bourdieu’s conceptualization of capital, habitus and field, and their interplay, from a post-structuralist perspective. Looking beyond the material aspects of SES, symbolic capital, cultural capital and social capital are all fluid and contextual. Different fields may value different types of capital due to the dynamic power relations embedded in certain fields. In the field of engineering, engineering-related/science capital (Archer et al., 2015) that helps cultivate engineering-related habitus can be more highly valued and bring more benefits to individuals who remain in this field. Habitus indicates how individuals internalize social structures and norms. It is enduring but changeable, thus social structures can be either reproduced or subverted. Habitus is not merely shaped by SES, but also by gender (Bourdieu, 2001). Female engineering students hence are more likely to develop a gendered habitus that conflicts with the masculine culture in university engineering programmes, by performing their gender according to gender norms. This kind of gendered habitus may drive them to leave this field as a career path after graduation. However, a higher level of science capital is argued to contribute to higher science aspirations (Archer et al., 2015). Therefore, from an intersectional lens, SES can potentially empower female engineering students to resist gender norms and persist in engineering. This chapter also provides a theorization of intersectionality and emphasizes that not all women are equally disadvantaged. Considering the intersectionality of gender and SES, this study can capture the more nuanced complexity of female engineering students' experiences and choices.

Following the theorization of SES, empirical studies examining the impacts of SES, and the intersectionality of gender and SES in STEM/engineering aspirations were interpreted based on my theoretical understanding. Higher-SES families are argued by many existing studies to encourage children's engineering aspirations because those families provide more science-related social and cultural forms of capital and habitus. Economic capital tends to have more limited implications in this case. This chapter also identified university as a field that can reinforce class inequality, and the previous chapter indicated that engineering programmes at university are often male dominated. Therefore, there is a solid foundation for this research targeting female engineering undergraduate students from the lens of intersectionality of gender and SES.

Unlike research focusing on gender, which overwhelmingly articulates women's disadvantages in engineering fields, there is a subset of studies that argue for a negative association between SES advantages and female students' pursuit of engineering as an academic discipline and professional career. These studies often justify their findings by portraying engineering as a lucrative career, one that lower SES students are more motivated to pursue. It is noted that these studies are based on super wealthy countries where the SES structures can be different from other less developed countries. For example, in the UAE (Aswad, Vidican & Samulewicz, 2011), affluent parents often have strong social connections with political elites and ruling families who can provide job opportunities for their daughters, so the daughters need not pursue engineering to secure a job or maintain their class privileges. The daughters also do not need to worry much about downward social mobility due to the substantial capital possessed by their family. However, the situation in China appears different. According to a quantitative study on maths aspirations (Liu, 2020), as a developing country where the educational resources are unevenly distributed, a higher SES can still encourage Chinese female students to pursue maths. Therefore, the contextual features of SES highlight the significance of this PhD research on Chinese female engineering students.

Three contributions of my thesis are identified in this chapter. First, although ‘science capital’ has received extensive attention in STEM education research, there is a lack of nuanced guidance to apply it to the engineering field, the higher education stage, or Chinese contexts. Therefore, a major theoretical contribution of this PhD research is that I reconceptualize ‘engineering capital’ for engineering disciplines and Chinese higher education contexts as a comprehensive and culturally sensitive methodological and theoretical tool. Second, there is very limited research about how gender and SES intersect to shape female engineering students’ career pathways in China. Nevertheless, SES is contextual, so this can be a significant gap in international research that my research will address. And among the small number of existing Chinese studies, there is a lack of qualitative investigation of how the intersectionality of gender and SES take effects. This again reinforces the necessity of mixed-methods research.

In summary, dominant discourses surrounding gender and SES in engineering fields in most societies tend to disadvantage women and individuals from lower SES backgrounds. During the engagement of female engineering students with varying habitus and capital within the engineering field, social structures exert significant influences, shaping their experiences and opportunities. Simultaneously, they actively exercise their agency to respond to and navigate these social structures, leading to different career choices of being inside and outside engineering. The upcoming chapter provides detailed theorizations and examples that highlight my understanding of agency, drawing from both sociological and psychological perspectives. It elaborates the various mechanisms, strategies, and decision-making processes through which individuals exercise their agency, shaping their interactions with broader social contexts and potentially changing or reproducing the social structures.

Chapter 4: Human agency: weapon or white flag?

Female engineering students are subject to both gendered and SES-related social structures, in the form of gender norms such as women's low perceived talent in engineering, and in terms of engineering-related social and cultural capital. Individuals actively participate in conforming to and subverting these social structures. They interact with these social structures through exercising their agency.

This chapter draws on key theories and opinions from Mustafa Emirbayer, Ann Mische, Margaret Archer, Albert Bandura and Robert W. Lent to illustrate agency. It begins with my understanding of agency, combining both sociological and psychological perspectives. I further explain the reciprocal relationship between agency and structure. Reflexive agency and social cognitive perspectives on human agency follow discussion of the sociological landscape. Some empirical studies on how agency plays a role in shaping engineering experiences and aspirations are interpreted at the end of this chapter. Decolonization of agency theory is also considered in a reflexive way.

4.1 Conceptualizing agency from both sociological and psychological perspectives

Agency, from a poststructuralist theorization, is a temporally embedded process of social participation, informed by the past (in a habitual way), but also future-oriented (being able to foresee various possibilities) and toward the present (being able to contextualize past habits and future projects within current circumstances) (Emirbayer & Mische, 1998). Accordingly, Emirbayer and Mische identified three analytical dimensions: the iterational element; the projective element; and the practical-evaluative element. Each dimension exhibits a simultaneous internal orientation toward past, future, and present due to the fluidity of agency. This means that all forms of agency are temporally situated, socially constructed, and related to specific social contexts (Emirbayer & Mische, 1998). Post-structuralism challenges the view of individuals as being stable, independent and coherent. Instead, agency is shaped by the complex power relations within the social structures (Harris & Dobson, 2015). As articulated by Blaise (2015), the disaggregated operational mechanism of agency helps to comprehend the interplay between the reproductive and transformative features of social relations, such as gender norms and SES structures in this research. It is important to note that agency does not passively accept the influence of social structures; instead, individuals actively participate in and respond to social structures. This dynamic process will be further illustrated in the next section.

A sociological conceptualization of agency places a greater emphasis on its social engagement, while a psychological understanding prioritizes understanding the internal processes and mechanisms through which agency operates within individuals. In this study, I further complement agency with a psychological understanding: it refers to the deliberative, cognitive and reflexive ability to make choices, as well as the ability to motivate and regulate the execution of actions (Bandura, 2006). Reflexive agency (Bandura, 2001, 2006) will be illustrated in Section 4.3 as a psychological perspective of agency. Human agency facilitates people, through self-efficacy – the belief that individuals can achieve their expected results through actions, to actively respond to social-cultural construction (Fu & Clarke, 2020). Bandura (2000) also regards self-efficacy as the core of human agency, since only when people believe that they are capable of producing desired effects and prevent undesired ones can they have the incentive to act. Studies have shown that engineering self-efficacy can predict the persistence of undergraduate students in engineering (Concannon & Barrow, 2010; Mamaril et al., 2016). The psychological view of agency can also be reflected in its categorization. There are two forms of agency: perspectives and actions. Agentic perspectives refer to thought processes that make sense of surroundings and contexts in order to advance personal goals, while strategic actions are steps taken to achieve their targets (Campbell & O’Meara, 2013; O’Meara et al., 2014).

Considering both sociological and psychological perspectives can help to better explore how agency interacts with social structures and how the functionality of agency comes to individuals. This approach can avoid the dualist understanding of agency of social determinism or individual voluntarism (Barnes, 2000; Hollway & Jefferson, 2005; McNay, 2000). In the context of my research, social influences such as gender and SES mediate how individuals exercise their agency in different ways to choose a career inside or outside engineering. This study employs the term 'engineering agency' to refer to the ability to actively participate in the process of negotiating access to engineering and maximising a person's advantages in the field, under sociological and psychological influences. Sociologically and psychologically, engineering agency and social structures can be seen as mutually constitutive and co-working. My analysis will thus be more comprehensive, considering both psychological and sociological elements within a post-structuralist perspective, by regarding agency not as a fixed attribute possessed by individuals, but as a contingent and relational process. It is also viewed as performative, enacted through power relations and social norms that shape individuals' actions and subjectivities.

4.2 Agency and structure

I regard the coexistence of individuals and the broader society as an interaction of agency and structure where the emergence of our 'social selves' occurs (Archer, 2007). Structure specifically means social-cultural structure, where rules and resources form an invisible net of power that constrains or enables individuals' actions (Giddens, 1981). Agency and structure are not dualistic, as they shape and are shaped by each other in a spiral, dynamic and conjoined manner of structuration (Giddens,1984; Fu & Clarke, 2020). Agency is subject to social constructions, it can thus be fluid, situational, and relational (Ebrahim, 2011; Xu, 2018). Human beings are not simply passive recipients of social experiences; instead, they actively participate in ongoing processes of reproducing or challenging the existing power dynamics and hierarchies that underpin social structures. Individuals 'are both constituted and yet can choose what we might be constituted as' (Jones, 1997: 266). To interpret this process using my post-structuralist view of power, individuals can choose to be ‘shaped’ by the structure and can also resist being ‘shaped’, depending on the power and affordances. Bourdieu’s concepts of ‘field’, ‘habitus’ and ‘capital’, illustrated in the previous chapter, can also be regarded as an interaction of structure and agency. Habitus creates the structures of the field, where different forms of capital define value; the field, in turn, mediates between habitus and practice in the field (Dowding, 2008). Structure and agency can be employed to investigate how students position themselves and are positioned by others in science education (Varelas, Settlage & Mensah, 2015). Female engineering students with different habitus, capitals and gender engage in various fields, including engineering, family, school, university and the workplace. These intersectional elements can be characterized as dynamic social structures that situate their agency. Social structures can shape individuals’ engineering habitus and subjectivities, leading to different choices of career pathways. Similar to habitus, as discussed in the previous chapter, subjectivity can be seen as an expression of agency (Salehjee & Watts, 2023). It is not fixed but rather characterized by fluidity and flexibility, allowing for potential changes over time (Mezirow, 2000). The transformation can occur in an inconspicuous way, often alongside micro-transformative experiences (Heddy & Pugh, 2015).

If individuals are agentic enough to resist social constructions, they can make choices according to their own desires and values, even though they may go against prevailing social structural norms. Therefore, such social structures and norms are fluid and subject to change as a result of human actions of agency, though power makes them appear stable and unchangeable. In some cases, people are influenced by structural factors and act in conformity with those constructions without awareness or unconsciously; Foucault (1997) argued that power operates in such a way that individuals may be subjected to its effects without necessarily recognizing or actively engaging with it. This is how power works to suppress agency and renders certain powerful structures hard to challenge. Individuals may only notice that their choices or behaviours are what they want to do in their heart, but do not realize that they may be the outcome of social influence (Archer, 2003). To be specific, some girls believe that they personally do not like engineering, but they are not necessarily aware that this feeling can be constructed by their social surroundings.

Although my study includes some psychological aspects of agency, I regard those psychological aspects as also being socially constructed. As Salehjee and Watts (2023) state, the sense of self of individuals is closely connected with their social surroundings; their thoughts may thus originate from and be influenced by cultural and social norms. Therefore, I hold that a woman exists both as an autonomous individual and as someone deeply intertwined in her social and cultural environment, shaping her beliefs and behaviours. Next, a psychological understanding through reflexive agency is discussed to show how agents – female engineering students in this study – consciously make their choices.

4.3 Reflexive agency

Archer (2003) asserts that individuals' reflexivity, the ability to know ourselves to be ourselves, which is internalized from society, can be regarded as the missing link that mediates the impact of structure upon agency. The influences from social structures can only be conditional and situational rather than deterministic (Archer, 2003; Bandura, 2001), as the reflexive agency of different individuals can withstand them to different degrees by diagnosing their situations and identifying their interests. Due to the exercise of reflexive agency, some social influences are immune to certain social agents, and individuals who initially share similar life chances can later follow different pathways. This also reflects the value of intersectional studies that consider the diverse social subjectivities of female engineering students, namely through gender and SES.

Reflexive agency, in accordance with the self-reflective nature of agency identified by Bandura (2001, 2006), can be regarded as taking effect in the form of internal conversations when individuals reflexively talk to themselves, having been a social being under the influence of their surrounding society, although relying on imperfect assessments of their potential circumstances (Archer, 2003). Archer (2003) conceptualizes internal conversations as active cognitive processes through which individuals exercise their agency by generating various courses of action in response to structural influences. She (2010, 2013) contends that Bourdieu's (1997) theory of practice downplays the significance of individual reflexivity and the role of human agency in shaping social outcomes and critiques his determinist account of the internalization of structure by individuals. As discussed in Chapter 3, while habitus plays a role in influencing and constraining agency, individuals can potentially transform their habitus and bring about changes in their behaviours and social positions. According to James (1891), the life of the mind has three ontological principles: interiority, subjectivity, and causal efficacy, so through internal conversation, individuals, in the face of structural impact, have a certain capacity to modify themselves and, through this, to affect their social surroundings in turn. The cyclical process can therefore be described as follows: structure exerts influence on agents, agents make the final decisions by reflexive agency (internal conversations), which then enables reproductions/disruptions to the structure.

The internal conversations are facilitated by reflexive deliberations, as described by Archer (2003, 2007), which encompass four distinct modes of reflexive engagement as below: fractured reflexives, communicative reflexives, autonomous reflexives, and meta-reflexives. Everyone can be reflexive but not identically, and individuals often possess more than one mode simultaneously (Archer, 2003, 2007; Baker, 2019; Bovill, 2012; Dyke et al., 2012). (These reflexive modes can be closely connected with Bandura's categorization of agency, discussed in the next section.)

- Communicative reflexives: People with communicative reflexives have initial internal dialogues but tend to seek suggestions from others to finalize their deliberations, reflecting their lack of self-efficacy.

- Autonomous reflexives: People with autonomous reflexives engage in internal activity without external exchanges with other people as they have self-sufficient inner deliberations.
- Meta-reflexives: This involves reflexivity about an individual's practice of reflexivity. They critically question and analyse their internal conversations, asking themselves why they express certain thoughts or engage in specific self-reflection. Meta-reflexives, featuring person-centred and empowering approaches, are regarded as crucial in challenging structural inequalities (Scambler, 2013; Goodman, 2017; Williams, 2018; Zhao et al., 2023).
- Fractured reflexives: Some people may encounter fractured reflexives at a certain period, meaning that their reflexives and internal dialogue are impeded. As a result, their self-conversation fails to give them practical guidance to act in line with.

It is important to be aware that these are decontexualised mechanisms that do not take into account the cultural diversity beyond the West. For example, Zhao and colleagues (2023) conducted a study that highlighted the more nuanced and context-specific manifestations of higher education participation in Cameroon, emphasizing a context-specific employment of reflexive agency. Additionally, a post-structuralist view of agency emphasizes the social constructions of agency and the process of negotiating power in hierarchical societies. Therefore, it is essential to consider the social contexts in China when applying agency-related theories.

In this study, reflective agency is employed to understand the psychological ways in which female engineering students exercise their agency in negotiating gender and SES social structures specific to the Chinese contexts. While Archer is considered pioneering for proposing a practical approach to operationalizing reflexivity and facilitating its empirical implementation, Caetano (2015) argued that this approach may overlook significant social factors and diverse dimensions necessary for a comprehensive and multi-dimensional study of the concept. By not adequately considering these factors, research may present a limited understanding of the complex nature of reflexivity and its interplay with social dynamics. This study thus employs a sociopsychological understanding of agency, viewing it as a reflexive and relational process within social structures.

4.4 Social cognitive perspectives

After exploring the interplay between agency and structure from a sociological standpoint, and the psychological process of reflexive agency, a sociopsychological perspective of agency is discussed in this section. Bandura (1986, 2012) developed the social cognitive theory, which emphasizes the reciprocal interaction between cognitive processes, behaviours, and the social environment. Applying this theory to the conceptualization of agency, Bandura (2000, 2001, 2006) identifies three categories of agency: personal agency, proxy agency, and collective agency. Additionally, based on Bandura's social cognitive theory, Lent, Brown, and Hackett (1994) coined social cognitive career theory (SCCT), which offers a framework for comprehending career aspirations and decision-making processes. Although I appreciate the efforts of SCCT in career studies, I choose not to use it as an umbrella theoretical framework in the context of my research, but it can be a justification of my own attempt to combine both sociological and psychological elements. This section provides detailed introductions and critical interpretations of the abovementioned perspectives.

4.4.1 Social cognitive understanding of agency

Bandura (2006) identifies four core properties of human agency that operate through consciousness: intentionality, forethought, self-reactiveness, and self-reflectiveness. First, agency refers to intentional acts grounded in self-motivators, although the outcome may be beneficial or detrimental as well. Second, people tend to continually plan ahead by considering anticipated outcomes to identify their priorities and map out their present to fit a desired future. Specifically, as a cognitive process, anticipation empowers agents to foresee potential obstacles or advantages associated with particular behaviours, enabling them to make informed decisions regarding circumvention or execution. Third, it is a process of self-regulation to shape certain courses of action grounded in personal goals and moral agency (the moral judgement of right or wrong) by monitoring one's behaviour pattern and the environmental condition. At last, agents are not only planners, fore-thinkers, and self-regulators; they are also self-examiners. Through self-reflectiveness, individuals work out conflicts in motivational inducements and opt to act in line with one over another. The metacognitive ability to reflect on oneself and evaluate the adequacy of one's thoughts and actions is a fundamental characteristic of human agency.

Taking individuals as producers of experiences and shapers of events, Bandura (2000, 2001, 2006) identifies three types of agency from a social cognitive perspective: personal agency, proxy agency, and collective agency. Personal agency is cognitively exercised to react upon social relations by individuals themselves. For students at university, empirical studies show that they consistently participate in processes that improve their academic skills through self-discovery and personal development (Chen, 2004), resilience and determination (Fuller, 2005) and resourcefulness (Eland, 2001). However, in some cases, personal agency fails to allow individuals to directly control social circumstances. Proxy agency is thus a case in which people try to get those who have expertise or power to act on their behalf to achieve desired results, such as peers, mentors, supervisors, and family (Bandura, 2001, 2017; Fuller, 2005; Woo, Jang & Henfield, 2015). For example, parents might provide suggestions and even make decisions for their children to choose an engineering major for university, particularly when students are not familiar with the university application process. Proxy agency requires authorization of others as proxy agents and this authorization is based on people's beliefs and reliance on the power of their proxy agents (Ludwig, 2017).

Proxy agency can either promote or impede self-development (Bandura, 2001). On the one hand, a blend of proxy agency can allow individuals to deal with issue they are incapable of, and be in a better position to avoid the risk of shouldering the responsibility of possible failure. On the other hand, if individuals consistently delegate decisions or actions to proxies without actively participating in the process themselves, they may miss out on opportunities for personal growth and development of decision-making skills. This double-edged sword can be seen as an interpretation of how habitus is shaped in different ways by the capital within certain power relations. From a post-structuralist view, proxy agency is embedded in socially constructed networks and power relations. The exercise of proxy agency is subject to social structures, such as gendered hierarchies and patriarchy in Chinese society.

Humans are inherently social beings rather than living in isolation; often individuals collaborate with others to achieve shared objectives that cannot be accomplished independently or through proxy agency. Collective agency thus contains the shared beliefs that joint efforts and shared knowledge can produce synergy to bring desired future outcomes and enhance individual agency (Bandura, 2000, 2001, 2017; Chant, 2017). Perceived collective efficacy can foster motivational and behavioural efforts to achieve common goals (Bandura, 2000). I tend to see collective agency as a potential approach to enhance or subvert the construction of social structures, which in turn affects personal agency and, in this study, female students' engineering agency.

Bandura's social cognitive categorization of agency highlights the multifaceted nature of human agency, recognizing that individuals can exert influence through their own actions, through proxies, and through collective efforts. Bandura (2017) states that successful functioning requires a dynamic blend of different modes of agency. For example, research focusing on choice of university conducted by Reay, David and Ball (2005) shows that the decision-making process is both social and familial as well as individual, which corresponds to collective, proxy and personal agency. Bandura (2017) also mentions that the relative proportion of each mode can vary across different cultures. Therefore, it would be useful to explore the pattern in China, where people tend to have a strong attachment to family and Chinese culture is often described as collectivist (Zhang & Chen, 2021).

When integrating Archer's (2003, 2007) four modes of reflexive engagement into the process of expressing agency based on Bandura's (2000, 2001, 2006) categorization, it becomes evident that autonomous reflexives can be regarded as the strategy employed to perform individual agency, while communicative reflexives, as a discursive resource, can facilitate the operation of both proxy agency and collective agency. In the context of my research, by articulating their perspectives, asserting their desires, and communicating their intentions with themselves, female engineering students highlight their autonomy and the exercise of their personal agency. Communicative reflexives can be used to advocate the involvement of authorized others and delegation of actions or responsibilities, functioning as a form of proxy agency. Some women can exercise their agency more freely to choose careers within engineering, possibly because they have more science capital from privileged families and their proxy agents are more familiar with the engineering industry. Additionally, through communicative reflexives, individuals can express their perspectives, negotiate their roles and relationships within groups, articulate shared values, contributing to the construction of collective subjectivities and meaning, thus fostering a sense of collective agency. Social interactions and networking with their engineering peers can reflect collective agency (Woo, Jang & Henfield, 2015). The social dilemmas, such as a lack of belonging, encountered by women learning engineering at university can thus serve as obstacles to the expression of collective agency. Collective agency also implies that if individuals, educational institutions, and workplaces can come together in stronger cooperation, with the shared goal of providing an enabling and inclusive learning and working environment for women in engineering, the biased social structures that exist can be better disrupted.

4.4.2 Social cognitive career theory

The process of making career decisions is influenced by a multitude of factors. These factors include personal characteristics such as gender, experiences at university and the workplace, payment satisfaction, perceptions of employability, and the availability of opportunities in specific fields or locations (Brown, 2004; Lichtenstein et al., 2009; Winters, Matusovich, & Carrico, 2012). Social cognitive career theory (SCCT), developed by Lent, Brown, and Hackett (1994), based on Bandura's (1986) social cognitive theory, provides a valuable theoretical framework for exploring the reciprocal interactions between personal, environmental, and behavioural factors that influence individuals' interests, choices, and performance outcomes in academic learning and career pursuit. According to this theory, individuals' academic and career aspirations and actions are shaped by interests, self-efficacy, and outcome expectations, as well as by the supportive or constraining factors present in their environment regarding different choices. The figure below presents the detailed relationships among these elements.

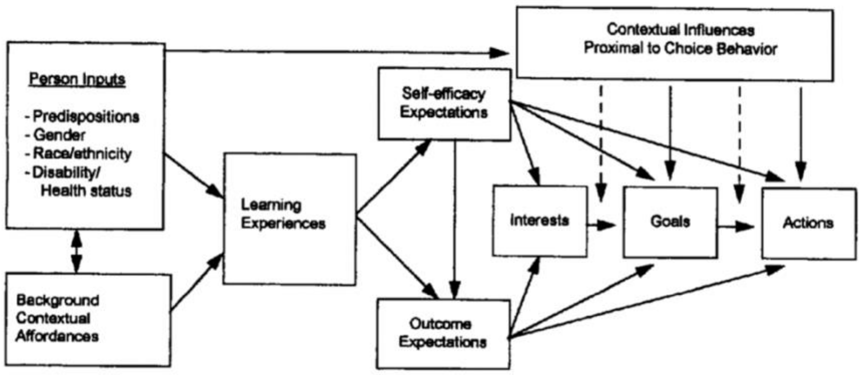

Figure 4-1 Social cognitive career theory (SCCT)

Those factors were categorized by Lent, Brown, and Hackett (1994) into two complementary levels of theoretical analysis within SCCT. The first level focuses on cognitive-person variables (self-efficacy, outcome expectations, personal goals) that empower individuals to exercise agency and shape their own career development. The second level of analysis explores how various additional factors, including physical characteristics (such as sex and race), environmental influences, and specific learning experiences, impact career interests and decision-making processes.

SCCT provides valuable insights to combine cognitive and social contexts in investigating career choices. This inspires me to combine both sociological and psychological elements to investigate the career choices of Chinese female engineering students. However, I find it is not necessary to employ SCCT as a guiding framework for my research for two main reasons. First, from the abovementioned two levels of theoretical analysis of SCCT (Lent, Brown & Hackett, 1994), we can tell that cognitive factors are more emphasized than social factors. SCCT's authors (2000) also admit that contextual variables receive much less attention in practical applications of SCCT. However, in my research, I maintain that contextual influences primarily impact individual career choices through the lens of agency (a term which is not explicitly depicted in SCCT), so my research places greater emphasis on sociological aspects rather than psychological aspects of agency. Besides the undervalued role of contextual influences, there is a widespread critique of SCCT regarding its superficial or simplistic application to empirical research, as it lacks qualitative research methods and assessment methods (Wang, Liu & Deng, 2022). Among STEM-related studies, a substantial portion of existing literature adopting SCCT tends to rely on quantitative methods to establish statistical relationships among different SCCT factors and different social groups, without delving deeper into understanding the underlying mechanisms of these relationships (Chan, 2022; Inda, Rodríguez & Peña, 2013; Navarro et al., 2014; Turner et al., 2019). In my research, an explanatory mixed-methods study, qualitative interpretation constitutes the major part. Therefore, I develop my own conceptual framework, integrating psychological and sociological elements to explore Chinese female engineering students' experiences and career choices: SES and gender are regarded as social structures that exert influences on Chinese female engineering students' agency, and agency functions in various forms through different modes of reflexives, thus finally affecting their career choices. Meanwhile, I acknowledge that agency can in turn reproduce or subvert social structures. Details on how this theoretical process works will be presented at the end of this chapter.

4.5 Agency interacts with gender and SES social structures to shape engineering choices

Through a continuous negotiation between agency and the social structures to which individuals belong, both opportunities and constraints for change can emerge (Gewirtz & Paretti, 2021). In the domain of higher education, various modes of reflexive agency have been widely explored in existing research, such as that of Muslim women in Australian universities (Al-deen, 2019), South Asian women in UK higher education (Bagguley & Hussain, 2016) and access to higher education participation in Cameroon (Zhao et al., 2023). Agency theory is also popular in gender studies, including research on women's collective agency in promoting gender equity in Egypt (Tadros, 2021) and exploring Pakistani women's empowerment in domestic and public spheres through exercising agency (Qureshi & Abid, 2022). Although my thesis does not aim to directly address these broad issues, there is a potential that it will inform future research and practical directions. Additionally, there is a limited amount of research focused on Chinese contexts when exploring the concept of agency – a gap that will filled by my study.

As noted in previous chapters, gender and SES social structures have intersectional influences on engineering aspirations and persistence. Gender norms such as women not being suitable for engineering that exist within family, schools and universities hinder female students' engineering engagement, while engineering-related capital can empower them to resist the gendered social structures. This section seeks to incorporate agency into this process of influence, as agency enables individuals to actively exert their power and make choices. Since a detailed literature review on gender and SES-related social structures in the domain of engineering/STEM was presented in Chapters 2 and 3, in this section I highlight a few selected studies that serve as representatives to investigate the role of agency more deeply. In Chapters 7, 8 and 9, I further explore how agency is embedded within the intersectionality of gender and SES-related social structures for participating female engineering undergraduate students in China.

Agency beliefs have been found to be significant in influencing the choice of an engineering career, with a stronger association observed among women than men (Godwin et al., 2016). Global research on the career choices of female students in engineering reveals that their agentic choice of an engineering career can be enhanced by a curricular atmosphere that fosters inclusivity rather than segregation based on gender, SES or minority status, and by support from important others such as parents, relatives, faculty members and classmates (see Amelink & Creamer, 2010; Espinosa, 2011; Ro, 2011; Sheppard et al., 2010; Villa et al., 2020). In these processes, except for individual agency developed within social structures, proxy agency and collective agency can also take effect. By engaging in communicative reflexive practices, engineering students can tap into the knowledge and expertise in engineering of proxies when they make decisions. Furthermore, an inclusive and supportive environment within the engineering classroom can nurture collective agency to work well with their engineering peers. It can promote their academic performance in engineering and their choice of an engineering career when these are the shared goals of engineering undergraduate students as a group. The interaction between agency and structure within power dynamics gives rise to fluid and changing subjectivities regarding engineering, including both affinity towards and detachment from the field (Archer & DeWitt, 2017; Moote et al., 2019a).

4.6 Summary

Connell (2007) criticizes the imbalance of global knowledge production, noting that the prevailing classical theories tend to be primarily constructed from Global North perspectives, which marginalizes the voices of the South. It is acknowledged that agency theories discussed in this chapter also provide insights into choices made by different agents in

Western contexts, while some research suggests that the assumptions of agency theory may not hold true in the context of Asian countries given the cultural differences (Ekanayake, 2004; Taylor, 1995). It is necessary to challenge the beliefs that Western ways of knowing are the exclusive representatives of science (Datta, 2018). Similarly, the role of decolonized non-Western agency is highlighted by Hobson and Sajed (2017) as an important component in world structures, which deserves intricate exploration. There have been attempts to decolonize agency in the education domain, such as the emphasis on southern agency in the domain of digital learning (King, Pegrum & Forsey, 2018). In my data analysis, I consider conventional values, social norms, and historical accounts that shape notions of agency in China. Studying agency in China contributes to a more global and inclusive understanding of this notion and allows for the recognition of diverse forms of agency that may challenge or expand Western-centric models of individualism and autonomy.

This chapter theorizes agency from both sociological and psychological perspectives within a post-structuralist framework. The sociological perspective on agency primarily focuses on its social engagement, emphasizing the ways in which individuals interact with and navigate through their social surroundings. Agency and structure are conceptualized in a way that challenges traditional binary oppositions and emphasizes their interrelated and mutually constitutive nature. Gender and SES are regarded in this research as socially constructed structures that are fluid and contingent upon historical and cultural contexts. Agency is viewed as a dynamic process situated in those gendered and SES structures. Individuals are not unified beings but are instead constituted by a multiplicity of subjectivities that are contingent upon power dynamics within societies. It highlights how individuals exercise their capacity to act and make choices within the constraints and opportunities presented by their social contexts, and in turn reproduce or subvert the existing structure. In other words, agency can be a weapon to fight social constructions, while it can also be a white flag for seeking peace and conformity.

On the other hand, the psychological understanding of agency places a greater emphasis on the inner mechanisms of individuals, exploring the reflexive processes underlying human action and decision-making. It investigates the individual's subjective experiences, beliefs, motivations, and intentions, seeking to understand how these internal factors influence the exercise of agency. Drawing on theories from Archer (2003, 2007) and Bandura (2000, 2001, 2006), I hold that human agency, including individual agency, proxy agency and collective agency, can be facilitated by the four modes of reflexive deliberations: fractured reflexives, communicative reflexives, autonomous reflexives, and meta-reflexives. While sociological perspectives emphasize the external and contextual aspects of agency, psychological approaches delve into the internal and individual dimensions. Integrating the two perspectives contributes to a comprehensive understanding of agency, acknowledging the interplay between agency and social structures in which it is embedded. SCCT was then discussed as a justification of my theoretical framework that combines sociological and psychological perspectives to investigate the career choices of female engineering undergraduate students in China. At the end of the chapter, empirical evidence on using agency to investigate women's engineering career aspirations was provided.

To summarize the theories and empirical studies elaborated in Chapters 2, 3 and 4, the agency of female engineering students is situated in the power relations within social structures of gender and SES, in a fluid and relational way, providing implications for their experiences and career choices. More specifically, through a 'heterosexual matrix' that is powerful and gender monoglossic, female engineering students perform their gender and form gendered habitus. Gender norms and public patriarchy derived from biological determinism usually discourage them from engaging with engineering. Therefore, as gender heteroglossia in the field of engineering, they usually obtain a lower level of engineering subjectivities, habitus and agency than their male counterparts. However, science/engineering capital can empower female engineering students to resist the gendered social structures by cultivating their engineering habitus. In this process, they engage with reflexive internal conversations to exercise their agency in different ways to make responses to the social structures around them, leading to different career choices.

Before delving into the next chapter, addressing methodology and findings, I present my own conceptual framework that guides my research and data interpretation to explore the experiences and career choices of female engineering students at Chinese universities. The conceptual framework acknowledges the significance of social structures, specifically gender norms and engineering capital, in which the agency of female engineering students is situated. These social structures exert influences – which tend to be masked by power relations – on their agency. Agency can be facilitated by different modes of reflexive deliberations, allowing female engineering students to make choices and act in ways that impact their career paths. It is also important to note that this is not a one-way process; agency has the potential to both reproduce and subvert the existing social structures.

Chapter 5 Methodology

Acknowledging the intertwined influences of structure and agency from a post-structuralist perspective, I adopt an interpretivist stance that allows for the exploration of experiences and perceptions of female engineering undergraduates within Chinese social structures (Alharahsheh & Pius, 2020). Gender and SES are regarded as two major social structures that shape the agency and choices of female students. The research method is designed based on this conceptual framework and the four research questions:

- How is science capital manifested in engineering disciplines in Chinese higher education?
- How are Chinese female engineering students motivated to learn engineering at university?
- What are the experiences of female engineering students at universities in China?
- How do gender and SES intersect to shape the career choices to continue in or leave engineering of Chinese female engineering newly-graduates?

The first question concerns the manifestation of science capital in Chinese contexts, which indicates the necessity to conduct a quantitative survey regarding the 'science capital index'. Besides this, due to the lack of related statistics in China, I chose to survey both female and male, year one to year four students to obtain a descriptive and statistical pattern of how gender and SES relates to Chinese engineering students' experiences and career choices. Semi-structured interviews were conducted with new female engineering graduates only to unpack how females of different SES backgrounds make subject choices and final career choices in the interplay between social structures and agency.

This research thus employs a sequential mixed-methods approach. Figure 5-1 shows the overall process of how I conducted the research in a more visual way. In this chapter, I first depict the ontological and epistemological positions underpinning this research design.

Then details of the quantitative part, including the survey design and its adaptation to Chinese contexts, data collection and data analysis, are presented. Similarly, the qualitative process is elucidated sequentially. Finally, I reflect on ethical considerations, my own positionality as a researcher, and potential methodological limitations of this research.

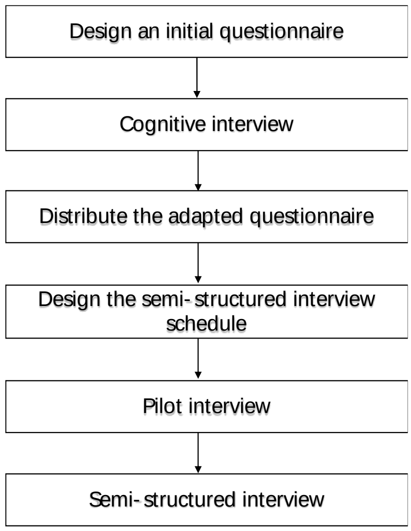

Figure 5-1 The mixed-methods approach

5.1 Sequential explanatory mixed-methods research

This study employs a sequential explanatory mixed-methods design (Creswell & Plano Clark, 2010), beginning with a quantitative survey, followed by qualitative semi-structured interviews. Although the two methods have different epistemologies and ontologies, they can complement each other in research practice, contributing to a fuller capture of the investigated phenomenon (Greene, Carcelli & Graham, 1989). Mainstream scholars before the 1970s viewed qualitative and quantitative existing within exclusive paradigms, while others started to see the potential in combining the two techniques (Guba & Lincoln, 1989). Mixed-methods research has subsequently developed into a distinct method, mixing both quantitative and qualitative approaches to understand a research problem (Creswell & Plano Clark, 2011).

Denzin (1978) outlined three outcomes to the mixing of methods: convergence/agreement, inconsistency, and contradiction of the findings from different types of data and their analysis. All three results can provide researchers with a value-added illustration of the observed social phenomena (Cara, 2017). Besides this, I agree with Ercikan and Roth's (2006) argument that the polarization of quantitative and qualitative research can be problematic because: (a) all knowledge touches upon both quantitative and qualitative elements; (b) the fixed adjective-noun pattern of objective quantitative research and subjective qualitative research is neither useful nor correct; and (c) attributing generalizability to only one of the poles can be dogmatic as generalizability aims to describe the tendency of inferences to go beyond the research sample and contexts, rather than being a characteristic of mathematization. Hence, integrative approaches providing the appropriate forms of knowledge needed by the research questions can be encouraged.

Several scholars argue for the freedom to break the rigid association between certain theoretical perspectives and methodologies, if it aligns well with their research purpose (see Crotty, 1998; Gray, 2013; Mackenzie & Knipe, 2006). In accordance with the approach employed by McChesney and Aldridge (2019), I designed my mixed-methods research based on an interpretivist paradigm, in order to look for 'culturally derived and historically situated interpretations of the social life-world' (Crotty, 1998: 67) and investigate the subjective world of human experiences (Cohen, Manion & Morrison, 2013). From a post-structuralist perspective, I regard social structures as fragmented and fluid, aiming to deconstruct the processes of becoming by exploring changes that are socially and culturally constructed (Hillier, 2012; Kwa, 2002).

In this case, the purpose of employing survey techniques is to gain insight into the prevailing landscapes that contextualize the qualitative elements, rather than to make statistical or probabilistic generalisations (ibid). It can also bring new statistics, which as mentioned are scarce in current Chinese academic literature. Some literature based on the data collected in Western countries I referred to in Chapters 2, 3 and 4 cannot be unproblematically transferred to Chinese contexts. The survey, which seeks to understand in a numerical way how science capital manifests in Chinese contexts, and subsequent interviews are the major methods used in this study. The qualitative elements can explain the pattern identified by the quantitative survey by exploring the dynamics and complexities of how gender and SES intersect to shape personal experiences and career trajectories. Overall, mixed-methods research is a reciprocal and complementary process: at research design stage, the analysed results of a quantitative questionnaire can inform questions as well as sampling in the second phase (explained in later sections); at the data analysis stage, the qualitive data can serve to interpret and clarify the quantitative results (Cara, 2017; Sieber, 1973).

5.2 Quantitative survey

Quantitative research aims to explain phenomena by collecting numerical data and analysing it using mathematically-based methods (Aliaga & Gunderson, 2000). As mentioned earlier, my survey does not aim to establish causality or generalize the results to the broader population. Instead, it informs the design of the interview schedule, helps to recruit interview participants, enriches the statistical pool within Chinese contexts and creates a framework that situates the qualitative elements. I explain each step of the quantitative approach in this section.

5.2.1 Design of the survey

The questionnaire is organized in five sections (the full version is attached as Appendix-I):

1) Demographics: self-identified gender, university information (type of university, year of study, field of study, academic performance) and family background (location, parents' highest education level, field of study and work, siblings and relatives' field of study/work and participants' monthly living expenses).

2) Science and engineering-related experience and beliefs before university: science and engineering-related family and schooling experience (the adapted science capital index).

3) Subjective beliefs in engineering: engineering agentic perspectives and actions； engineering image stereotypes.

4) University experiences: motivations to choose engineering as their subject to learn; classroom experiences, after-class engineering activity experience and internship experiences.

5) Career aspirations: future plan and reasons; who do they seek advice from for career choices.

Variables in sections (1) and (5) are categorical variables, while those in sections (2), (3) and (5) are numerical variables. Likert scale, multiple choice questions and a small number of open-ended questions were included in the questionnaire, at the end of which respondents were asked whether they were willing to participate in follow-up interviews. I used the UCL-approved online survey tool ‘Online Survey’ to collect the survey data. Based on the survey results, potential interview questions and participants from diverse backgrounds were more effectively identified. More analysis details are found in Chapter 6.

The survey questions for categorical variables were based on the research questions and literature reviewed, while the items for numerical variables were adapted from the following well-established survey instruments, with a few revisions to formats and wording. The advantage of using previously established scales is that they have already been validated, and their further use then builds knowledge in the fields.

1) Student Leaving Engineering Survey; and Student Persisting in Engineering Survey (AWE, 2007a; 2007b): These two tools relate to the university experience of engineering students regarding their persistence in this field of study. I picked up several sections, such as learning experience and internship experience and changed some wording to make it better fit Chinese contexts and my research topic.

2) Science capital index (Archer et al., 2015; DeWitt et al., 2016): This is the measurement of the key theoretical concept ‘science capital’ used in this study. It contains 14 items that are most closely related to a dependent measure of future science affinity and science identity. These 14 items, corresponding to the dimensions of science capital, contain science-related cultural capital, social capital and behaviours. It was applied in my questionnaire with some revisions to adapt it to Chinese contexts, as detailed in Section 5.2.3.

3) Sustainability and Gender in Engineering survey (SaGE) (Godwin, 2014): This instrument mainly contributes in terms of engineering agency. Although it focuses on engineering, it also considers maths, science and physics in the survey, as the target participants of this survey are students before university when engineering is not a required subject. Thus, I replaced ‘maths, science and physics’ with ‘engineering’ in my survey targeting university students in engineering programmes.

4) Agentic actions and agentic perspectives of career development (O’Meara et al., 2014): There are some overlaps on agentic perspectives between this tool and the above SaGE tool (Godwin, 2014) regarding agency, so these tools were combined in the service of my own research aim regarding engineering agency. I also replaced ‘career goals’ in this instrument with ‘(engineering) professional capability’ to make this survey more focused on engineering agency.

Integrating these, I created my own survey to provide some background statistics on how gender and SES are associated with engineering experiences and career choices in China. Nevertheless, I noticed that the abovementioned survey tools were all designed based on Western contexts, highlighting a lack of Chinese indigenous tools. If I literally translated the questionnaire into Chinese without any adaptations, Chinese participants may have been uncomfortable or confused about some items related to distinctive cultural backgrounds, different educational systems and improper translations. Therefore, I employed a cognitive interview strategy to adapt the largely Western-based survey to the Chinese contexts.

5.2.2 Cognitive interview

I piloted the survey with a small group of students (N=5, demographic details in Table 5-1) in February 2022 in the form of a cognitive interview, following ethical approval. Participants were invited to voice any confusion or hesitations they encountered when responding to the questionnaire. This 'think-aloud' methodology helps establish the cognitive validity of an instrument, which helps to ensure that participants understand the survey items (Trenor et al., 2011). The detailed process of how I conducted the cognitive interview can be found in my blog post published by British Education Research Association (Liu, 2022). Survey responses of all the think-aloud participants were discarded after I refined the survey instrument; they had been informed that their answers would not be analysed as part of the quantitative results. After completing the interviews, the participants were thanked for their participation by receiving the advertised incentive (30 RMB for each online participant and a cup of coffee of similar value for each face-to-face participant).

Participant	Gender	Family background	Year of study	Type of university	Way of meeting
1	Male	Urban area	Year 4	First-tier university (non-985/211)	Face-to-face
2	Male	Urban area	Year 3	First-tier university listed in Project 211	Online
3	Female	Urban area	Year4	First-tier university listed in Project 211	Online
4	Male	Rural area	Year 2	First-tier university (non-985/211)	Face-to-face
5	Female	Rural area	Year 1	Second-tier university	Online

Table 5-1 Demographic information of cognitive interview participants

Following the suggestions of Willis, Royston and Bercini (1991), I categorized problems participants faced when interacting with the questionnaire as structural issues and cognitive issues, with the acknowledgement that some issues touch upon elements of both categories. Structural issues include grammatical errors and problems in the design of survey structure. Cognitive issues refer to those problems that may cause misunderstandings. Table 5-2 shows major issues identified by participants and how I revised the survey based on their feedback.

	Survey questions	**Revisions**	**Major issues identified by cognitive participants**
Structural issues	Who did you talk to about science and engineering?	The option 'directly with scientists' was moved to the end of the list, just before the option 'other' and 'nobody'.	The sequence of answer options was weird, as only a few people have chance to talk directly with a scientist.
	Rank your top three choices from 1 to 3 (with 3 being the most frequently).	Deleted.	Ranking was regarded as time-wasting because it takes much time to make a decision.
	For each activity indicate your level of involvement during the most recent year you were enrolled in university.	Put the option of 'I don't know we have one' before 'not involved'.	The option 'I don't know we have one' might be skipped due to the sequence.
	Which of the following science and engineering related frequency best describes your situation before you went to university?	Add an option 'Once every few years'.	Previous frequency on science activities was regarded as too frequent.
	Father/mother's highest education level/field of study	Add an option: I don't know.	Some participants don't know their parents' highest education level and the field of study.
	Please list words or phrases that come to mind when you think of an engineer and what they do at work.	Deleted.	It was time-consuming when thinking about an answer for this gap-filling question.
	How much do you have for monthly living expenses from your parents at university?	'Interval: 1000 RMB' was changed into 'Interval: 500 RMB'.	The interval between each answer choice is too large.

Cognitive issues	-	‘Science(科学)’ → ‘Science and/or engineering subjects (理工科)’.	The word ‘science’ is hard to define if without any explanation, as this word is seldom used in daily life in China.
	How often did you go to after school science club before university?	‘after school science club（课后科学俱乐部）’→‘after school interest-oriented class in science and engineering subjects (理工科相关的课外兴趣班)’	‘After school science club’ is not familiar for Chinese students.
	My teachers have specifically encouraged me to continue with science after GCSEs	My teachers have specifically encouraged me to continue with science and engineering subjects after subject divisions from year 2 in high school.	GCSEs is not familiar for Chinese students.
	-	‘STEM subject/ non-STEM subjects’ → ‘Engineering subjects/ Science subjects/ Agriculture subjects/ Medicine subjects/ Art subjects’.	For questions related to the subject classification, it was hard to define what are STEM subjects by participants themselves.
	-	At necessary places, ‘engineering (工科)’ → ‘e.g. my programme, professional learning(专业)’.	Mentioning ‘engineering’ all the time can be confusing, as participants are from different sub-disciplines under engineering.
	When you had an academic problem in engineering, what did you do?	Add an option: online searching.	Newly added answer options containing new contents suggested by cognitive participants.
	What do you want to do after you finish your master/PhD?	Add an option: non-engineering jobs at an engineering related company, such as marketing.	

Table 5-2 Major issues identified by cognitive interviews and the revisions made

As my first research question touches upon translating and theorising science capital into Chinese contexts, I illustrate how the cognitive interview informs the localization of the science capital indicator – science capital index – below.

5.2.3 Localization of science capital index

Bearing in mind the Chinese context and the characteristics of the target sample, I made some revisions to the original science capital index (Archer et al., 2015; DeWitt et al., 2016;

Moote et al., 2019b; Moote et al., 2020) based on the cognitive interview feedback so that it could better serve my research. The adapted and original versions of the science capital index are attached in Appendix-II. The revisions are highlighted in red in the adapted version. Detailed illustrations on how and why I made the major revisions based on the cognitive interview are as follows.

First, the biggest difference between my research and Archer's is that my survey participants are Chinese university students, while the participants in 'science capital' studies are UK students prior to university. It was thus necessary to ask my participants to reflect on their experiences and perceptions before university when responding to items in the science capital index. To justify this movement, I asked during the cognitive interviews, 'to what extent are you confident that your memories of your pre-university thoughts and experiences are accurate' and 'if you were asked to answer those questions with reference to your university experience, would your answer change'. All five cognitive participants agreed that there had only been a few changes for answers of most of the science capital questions no matter whether university experiences were excluded or not, except for frequency questions on science and engineering activities engagement. Also, they had no difficulty accessing their memories to answer the questions. Therefore, in the survey, I asked: 'please think back to the experiences and beliefs you had before you arrived at university' in bold characters right after the science capital items. It was thus clear that the science capital index was adopted to capture the pre-university experience.

Second, the definition of the key term 'science' in items related to the science capital index was mentioned as being confusing by four cognitive participants, as they seldom touched upon this word in their daily life. One participant even regarded social science as a kind of science, which can be true but is not what my study wished to investigate. I consulted two researchers in Archer's team (ASPIRES project), Dr Ada Mao and Dr Spela Godec, about how UK students defined the word 'science' in their previous research. They said that most

UK students in quantitative survey regard ‘science’ as ‘school science’. Apparently, the literal Chinese translation for the word ‘science’ does not have the same connotation. There may not be a straightforward way to translate it into Chinese, because it is so different in various contexts. School science in China includes physics, biology and chemistry. Lu (2020) also reminded her survey participants that science refers to these three subjects when she translated the science capital index tool into Chinese. Considering these issues, I thus translated ‘science’ into ‘science and/or engineering subjects’. This may have narrowed participants’ understanding of the word ‘science’ and it will be acknowledged as a limitation in Section 5.5.

Furthermore, Spela reminded me that in UK contexts, STEM usually does not refer to the specific four subjects; instead, it emphasizes a combination of these four different subjects as an umbrella term. It is worth noting that from the general understandings of the public, there are some overlaps among the four terms such as technology and engineering. Based on the results of cognitive interviews, all the participants regarded information technology as an engineering subject at university. It would thus be difficult to separate those four subjects in Chinese cognitive contexts. Ada added that STEM is not a word that is understood by everyone, especially school children. This is a consideration when they use ‘science’ rather than ‘STEM’ when doing surveys in the UK. Therefore, it is acceptable to translate ‘science’ into ‘science and/or engineering subjects’ in Chinese. It also lays the groundwork for my endeavour to theorize ‘engineering capital’, particularly within the context of China, in Chapter 10.

Third, an essential difference in education system needs to be emphasized here. UK students take General Certificate of Secondary Education (GCSEs) in Grade 11 after which they have two more years in high school. The next step is A-levels, when they must choose from several subjects. They might stay with the same teacher in the same school after GCSEs. This is similar to what Chinese students experience at the beginning of their second year at high school. They are required to choose three subjects from physics, biology, chemistry, history, geography and politics (Wang, 2016; Wu, 2018). Therefore, the item 'my teachers have specifically encouraged me to continue with science after GCSEs' was modified into 'my teachers have specifically encouraged me to continue with science and engineering subjects after subject divisions from year two at high school.'

Finally, previous frequency options on attendance of science activities, such as visiting science museums and aquariums, was regarded as being too frequent by three cognitive participants. This might be because in China, the museum industry has not flourished as it has in the UK. Meanwhile, the Chinese K-12 curriculum system tends to neglect the role of museum resources, as is common in Western nations (Kang, Anderson & Wu, 2010). For many students, a museum tends to be seen as a scenic spot when students travel, rather than a regular place for learning (Li & Gu, 2022). 'Once every few years' was thus added as a frequency option. Also, all participants complained that they had never heard of an 'after school science club'. I thus replaced it with 'interest-oriented after school science and engineering class' so that Chinese responses would be aware of what it tends to mean.

I am aware that my survey participants may have overall high levels of science capital because they had already chosen engineering subjects at universities. However, my assumption was that among those with high science capital, those with even higher volumes would be more likely to choose engineering-related careers after graduation.

5.2.3 Quantitative data collection

5.2.3.1 Survey sampling

The design of this research included two stages, and the sampling was also sequential. Purposive sampling strategies were employed to select participants (Robinson, 2014). The online survey targeted both male and female engineering undergraduates in their first to final years at universities in Shandong province. Considering the vast size and large population of China, covering many provinces would introduce many complexities. It was decided to limit the context to a single province in China. Considering Shandong province is my hometown, it would be easier for me to recruit a satisfying number of research participants. More importantly, Shandong province is the hometown of Confucius and the origin of Confucianism, carrying pronounced Confucian ideology. The central government pays high attention to promoting Confucian cultural values in Shandong province, considering it a leading influence that can affect the entire nation (Jin, 2021). Shandong province thus provides a typical reflection of Chinese contexts. Section 6.3 illustrates how my quantitative sample can be representative of the intended focus population.

Target universities range from top ones (e.g. universities listed in Project 985) to third-tier universities. This is not merely to capture different university environments, but also to cover diverse SES backgrounds, as students from working-class families are more likely to attend less-renowned universities, while world-class institutions tend to have more middle-class students (Reay et al., 2001; Shen & Zhang, 2015; Zhou & Yue, 2019).

5.2.3.2 Survey recruitment

Convenience sampling was employed to source voluntary survey participants, with the aim to recruit a sample that was more accessible, rather than achieving generalizability (Sarker & Al-Muaalemi, 2022). I am aware of the self-selection bias that cannot be avoided in this recruitment mode (Costigan & Cox, 2001). Under the circumstances of my research, students with a higher interest and inclination of working within engineering would be more likely to agree to respond to the survey; this is acknowledged as a limitation that could potentially influence the findings.

The overall recruitment can be considered quite personal, as I did not distribute my survey through official channels. I tried to contact the engineering departments of two universities, but after they looked at my survey, they refused to help, saying that they needed to protect their students' privacy as the survey touches upon personal information such as students' family backgrounds. One staff member even strictly told me that as my survey is based on a foreign website, it could not be officially distributed by her faculty to the students since her university is conscious of national security issues.

I made full use of my personal contacts to get a fair number of survey responses. My father, a high school teacher, and my friend, a lecturer in the mining engineering department at a university in Shandong, were instrumental in recruiting survey participants. My father contacted his former students, now learning engineering in various university years in Shandong province, to fill in the survey. To avoid the homogeneity bias of having too many samples are from my city, snowball sampling was employed by asking his students to distribute the survey through their class WeChat groups, aiming to reach more engineering students from various cities. My friend shared the survey with engineering students in his university and contacted colleagues working at other universities in Shandong province to roll out my survey to broaden the responses. The recruitment lasted over two months from April 2022 to June 2022. With the help of my friends, family and participants, I finally received a total of 607 responses.

5.2.3.4 Survey language

The survey was initially designed in English and then, with Bachelors and master's degrees in English-Chinese translation and interpretation, I translated it into Chinese. A cognitive interview strategy (Section 5.2.2) was then adopted to embellish the translation so that Chinese responses did not feel confusing or uncomfortable in terms of the language used. The cognitive interviews were conducted and analysed in Chinese as well. When analysing the survey data, I translated the survey items and answers for open-ended questions back to English.

5.2.4 Quantitative data analysis

The analysis of survey results aimed to provide an overview of gender and SES and how they matter in Chinese contexts. This analysis created a statistical background against which I could explore the qualitative real-life complexities.

Descriptive statistics were reviewed using SPSS software to provide an overall account of my sample. Categorical variables were analysed by calculating frequencies and percentages, and Crosstabs with Pearson's chi-square test was employed for comparison. Numeric variables were examined using an independent-samples t-test to determine if different gender and SES backgrounds as social structures affected participants' science capital volume, engineering agency items, university life, engineering image stereotypes and career aspirations. The written answers from open-ended questions were analysed using both statistical methods (Crosstabs with Chi-square) and content analysis (calculating frequencies of themes). The detailed analytical process and results are presented in Chapter 6. Based on these results, three opinion questions on the survey findings were created in the semi-structured interview schedule. I also tailored specific questions targeting the six participants recruited from the survey that aimed to unpack in more detail their answers in the questionnaires during the interviews. Their answers were integrated with the overall interview data in the process of analysis. After confirming that science capital, engineering agency, engineering image stereotypes, university experiences and career aspirations can be different among samples with different gender and SES backgrounds, the overall interview schedule covered similar topics to the survey but with different sequencing, as noted in the next section. The interview schedule with key questions is attached as Appendix-III.

5.3 Qualitative semi-structured interviews

The interviews serve to understand how participants interpret the patterns identified from the survey, in relation to their own experiences and as situated in their broader social contexts. This can also reflect how structure and agency are contextually and culturally specific. Through qualitative interviews, complex and changing details, such as feelings and perspectives, can be extracted (Creswell & Poth, 2018). Subjectivities experienced outside of the interview can be reflected upon within the interview (Black & Williams, 2013) – factors that are difficult to obtain through singular quantitative research. This method, therefore, allows me to identify the key aspects or factors that engineering students narrate in constructing their subjectivity as engineering students in China and how these factors take effect in shaping their subject and career decisions. Moreover, interviews can help to highlight whether any forms of expressing science capital were not included in the survey – those that are specific to Chinese higher education contexts.

To capture these processes and manifestations, I employed in-depth semi-structured interviews, which are among the most frequently used strategies in qualitative research due to their versatility and flexibility (Kallio et al., 2016). For semi-structured patterns, the formulated interview questions only offer a guiding structure rather than strict rules to follow. The interviewer can improvise follow-up questions based on participants' narratives (Hardon et al., 2004; Polit & Beck, 2010; Rubin & Rubin, 2005). This format also allows more space for participants' individual verbal expressions. It thus enables reciprocity between participants and the interviewer (Galletta, 2012). In such an enabling and inclusive atmosphere, I expected to gain a richer understanding of female engineering students' choices and the roles that gender and SES play in their experiences and choices.

5.3.1 Qualitative data collection

5.3.1.1 Interview sampling

The interviews targeted newly graduated female engineering students from universities in Shandong province. In this way, I aimed to explore the final career choices of at least some of them, as some chose to pursue master's degrees. I did not interview male students, as I aimed to focus on women's experiences as a whole and to provide a complex picture of how those female students chose or planned to choose a career within or outside engineering.

As Gobo (2008: 197) noted, 'When we do not possess complete information about the population, samples are selected according to their status on one or more properties identified as the subject matter for the research'. This study considered gender, SES, university type, graduation choice and career choice when selecting appropriate participants.

5.3.1.2 Interview recruitment

The initial and ideal plan was to recruit all interview participants from the survey. Unfortunately, I met a technical issue in the operations of the Online Survey platform. It would have preferred if this message could have been shown only to final year female students, but the platform would not accommodate this desire. In this case, I could only state clearly in the message in the end of the survey that 'we will need some female students in their final year at university'. However, some survey responses did not read the message carefully. I received dozens of contact numbers, but when I checked their eligibility, I found that some were male, and some were year one, two or three students (programmes at Chinese universities usually last four years). After screening the information, I was left with only six who were eligible and willing to take part in the interviews.

The survey failed to provide me with as many interview participants as expected, meaning that I needed to recruit more participants in other ways. Online advertising and snowballing strategies were thus employed to source voluntary interview participants (Robinson, 2014). Due to the Covid-19 lockdown scenario, the recruitment process was conducted online. While some disadvantages of online advertising have been identified, such as the potential for a biased sample of individuals with higher education, income, and younger age (Hamilton & Bowers, 2006), it appears that it had limited influence on my sampling process. This is because I specifically targeted female engineering newly graduates to participate in interviews. At the same time, I found that snowballing from existing interview participants could be an effective route, so I re-submitted my ethical application to the UCL ethics committee, adding snowballing as another approach for interview participants recruitment. I asked existing participants for help after their interviews so that I did not add additional pressure to their attending the interview. Specifically, I asked if they could contact their friends or classmates who were eligible to see whether they were interested in taking part in my interviews. To avoid homogeneity, such as having half of the interview participants from the same university, each participant was only encouraged to find no more than two new participants through their personal contacts. In the end, I recruited 24 new female engineering graduates to take part in semi-structured interviews, with the acknowledgment that these participants do not aim to represent all Shandong female engineering graduates or Chinese female engineering graduates. Instead, the 24 interviews mainly help to explore the 'qualitative richness of the phenomenon' (Fereday & Muir-Cochrane, 2006: 4).

5.3.1.3 Interview participants

The participants for semi-structured interviews were all females who had graduated from universities in Shandong province with a bachelor's degree in engineering in 2022. They were from different SES backgrounds and had made various choices after graduation. Table 5-3 shows information on the semi-structured interview participants – their personal data were all anonymised. To ensure the potential participants are eligible, before the interviews, I sent them a short question list about their gender, field of study, graduation time, family location (rural or urban areas), choices after graduation and career decisions. After the confirmation of all information, I sent them the information sheet, consent form and my interview schedule, usually a week before the interviews, so that they had enough time to read the materials and prepare.

They were given complete freedom to choose between online or face-to-face forms of interview. Due to Covid-19, universities were locked down, and to avoid any potential exposure to the virus, many participants tended to choose the online form of interview (Lobe et al., 2020; Pocock et al., 2021; Brown, 2022). Even though three participants initially agreed to meet face-to-face, two changed their minds when the virus became more severe in winter. Therefore, 23 interviews were conducted online, and only one in person. Compared with face-to-face interviews, online interviews have been praised for their advantages in enhanced convenience for participants, overcoming geographical and access-related barriers, and providing more uninhibited responses on sensitive topics (Williams et al., 2012; Sah et al., 2020; Varma et al., 2021). Nevertheless, they also present difficulties in building rapport between participants and researchers and in detecting non-verbal cues (Salmons, 2012; Tremblay et al., 2021). I thus conducted the online interviews in a conscious way to carefully mitigate these disadvantages, such as initiating more warming-up questions, and paying close attention to the ups and downs in participants' tones to compensate for the absence of non-verbal cues.

The first semi-structured interview took place on 10 October 2022. As some of my participants (N=3) were preparing for their second try at the Postgraduate Entrance Examination which takes place in the end of December each year, their interviews were delayed to the beginning of January 2023. Thus my overall qualitative data collection period spans October 2022 to January 2023.

The duration of the interviews ranged from 45 to 110 minutes, with most lasting around one hour. There was an exception where one participant refused the audio interview, preferring to type online to answer my interview questions. Ethically, I did not ask for any reason and I agreed to do this 'text-based interview' via WeChat, which took us four hours to finish. This is one of the synchronous approaches of online interviews conducted through text-based chat rooms, as identified by Stieger and Gortiz (2006). Both the researchers and participants have more time to edit texts before sending them, although this can lead to the disadvantage of it being time-consuming and the difficulty of interviews drawing instant attention from participants when they diverge from the intended topic (Girvan & Savage, 2013). This is acknowledged as a limitation in this single case. In addition, it is argued by some researchers that text-based interviews pose challenges for verifying participants' personal identities, such as gender in this study (ibid). However, as I regard gender as being fluid and fully respect participants' self-identifications of their gender, I analysed the data based on the participant's self-identification, encompassing both biological sex as female and social gender as women.

No	Name	Field of study	University type	Family location	First-gen. student?	Engineering-related family?	Plans after graduation	Career choices/ aspirations	Interview method
1	Shi*	Mechanical engineering	University listed in Project 211	Urban area	No	Yes	Master, inside engineering	Outside engineering	Online
2	Ju	Food Science and Engineering	Third-tier university	Rural area	Yes	Yes	Master, inside engineering	Inside engineering	Online
3	Yu*	Mechanical engineering	University listed in Project 985	Urban area	Yes	Yes	Master, inside engineering	Inside engineering	Online
4	Mai	Mechanical engineering	University listed in Project 985	Rural area	Yes	Yes	Master, outside engineering	Outside engineering	Online

5	Ren*	Computer science and technology	University listed in Project 985	Urban area	No	No	Master, inside engineering	Outside engineering	Online
6	Jin*	Environmental Engineering	First-tier university (non-985/211)	Rural area	Yes	No	Master, inside engineering	Inside engineering	Online
7	Hai*	Civil engineering	First-tier university (non-985/211)	Urban area	No	Yes	Work, outside engineering	Outside engineering	Online-typing
8	Xiao	Computer science and Engineering	University listed in Project 985	Rural area	Yes	Yes	Work, inside engineering	Inside engineering	Online
9	Zheng	Civil engineering	Third-tier university	Urban area	Yes	Yes	Master, outside engineering	Outside engineering	Online
10	Hee	Vehicle Engineering	Second-tier university	Rural area	Yes	Yes	Master, outside engineering	Outside engineering	Face-to-face
11	Die	Vehicle Engineering	University listed in Project 985	Rural area	Yes	Yes	Work, inside engineering	Inside engineering	Online
12	Hou	Geological Engineering	Second-tier university	Rural area	Yes	Yes	Master, inside engineering	Outside engineering	Online
13	Xiang	Civil engineering	Second-tier university	Urban area	Yes	Yes	Master, inside engineering	Inside engineering	Online
14	Fu	Geomatics Engineering	Second-tier university	Rural area	Yes	No	Master, inside engineering	Outside engineering	Online
15	Kai	Civil engineering	Second-tier university	Urban area	Yes	yes	Master, inside engineering	Inside engineering	Online
16	Mo	Materials science and engineering	University listed in Project 211	Urban area	Yes	No	Master, inside engineering	Outside engineering	Online

17	Yi	Software engineering	First-tier university (non-985/211)	Rural area	Yes	No	Work, inside engineering	Work, inside engineering	Online
18	Xu	Computer science and technology	Second-tier university	Urban area	No	Yes	Master, inside engineering	Outside engineering	Online
19	Xin	Mechanical engineering	Second-tier university	Rural area	Yes	No	Work, inside engineering	Work, inside engineering	Online
20	Li	Geography and urban & rural planning	First-tier university (non-985/211)	Urban area	Yes	Yes	Master, inside engineering	Outside engineering	Online
21	Chen	Computer science and technology	Second-tier university	Urban area	Yes	No	Master, inside engineering	Outside engineering	Online
22	Cai	Geographic information science and engineering	University listed in Project 985	Urban area	No	Yes	Master, outside engineering	Outside engineering	Online
23	Yang*	Materials science and engineering	First-tier university (non-985/211)	Urban area	No	No	Master, inside engineering	Inside engineering	Online
24	Rui	Civil engineering	First-tier university (non-985/211)	Rural area	No	Yes	Master, inside engineering	Outside engineering	Online

Table 5-3 Semi-structured interview participants.

* interviewees recruited from the survey.

5.3.1.4 Pilot interviews

The qualitative pilot study was designed to improve the survey-informed preliminary interview schedule that sits at the heart of interviewing, to obtain some early evidence on the viability of this research, and to enhance my practical skills in conducting semi-structured interviews (Majid et al., 2017). Two pilot interviews were carried out on 14 August 2022 and 18 August 2022. I randomly picked one from the six participants recruited from the survey and used my personal contacts to reach another newly graduated female engineering student for the pilot interviews. They are the first two participants presented in Table 5-3 and they both chose an online form of interview. Zoom was used to conduct the online interviews. The interviews were recorded both on my phone and via Zoom Meeting in case of any potential technical breakdown. The two pilot interviews lasted 65 and 68 minutes each, which was the planned length.

Field testing informed two major changes to the interview schedule. The first change was the sequencing of the questions. The initial interview questions were designed based on the topics in the survey – family backgrounds, science capital, engineering agency, engineering image stereotypes, schooling experiences, university experiences, and career aspirations. However, I found from the pilot interviews that some topics covered repetitive content and engineering agency did not need a specific question because I can take this from their narratives of their experiences. I thus deleted the questions about engineering agency and organised the questions in chronological order from schooling experiences to post-graduation experiences. The second change was to ask my questions in a more inclusive and open way as I found that answers of my pilot interviewees tended to be short. My previous questions may have been overly specific, resulting in answers that were accordingly limited and constrained, and I thus may not have provided them enough space to tell their stories freely. As the revisions were mainly about the question sequencing and format, rather than the content, I included the pilot data in my overall qualitative data analysis and presentation, described in Chapters 7, 8 and 9.

The pilot interviews also helped enhance my semi-structured interview practice, especially the flow of conversation. When I read the transcripts of the two pilot interviews, I marked places where I should have asked further questions but did not, and made notes on how to ask follow-up questions. This improvisatory process can be an advantage of semi-structured interviews, but it needs rigorous operation so that the study is more trustworthy and the results are more plausible (Kallio et al., 2016). Reflections on a more effective way to ask follow-up questions help to add rigor as well as richness to my overall qualitative data collection.

5.3.1.5 Interview language

The semi-structured interviews, including the pilot interviews, were all conduced in Chinese, as many of my participants were not proficient in speaking English so that they may not have expressed themselves well in English. The interview data was also analysed in Chinese to make the whole process more efficient as I did not need to translate all the transcriptions. After deciding which extracts were used in the thesis, I carefully translated them into English.

5.3.2 Interview data analysis

Being more interrogative and interpretative, I aim to go further than just describing participants' stories but to look 'beneath the surface' of the data (Braun & Clarke, 2013: 174). Braun and Clark (2013) note that thematic analysis (TA) can be used to identify potential concepts and ideas that underpin the explicit data content. TA was thus applied to my interview data to observe the complexity of the phenomenon and how individuals make sense of their experiences and choices.

TA refers to the search for themes in transcripts as being an essential part of describing a phenomenon (Daly, Kellehear & Gliksman, 1997). Though it was first developed in the 1970s by physicist and historian of science Gerald Holton as a named method, it has since been accepted as a distinctive and popular approach with a clearly outlined set of procedures for the social sciences (Braun & Clarke, 2006). As Braun and Clarke (2013) state, flexibility is one of the major strengths of TA. Themes can be identified in a data-driven, 'bottom-up' way (Boyatzis, 1998), as well as in a more 'top-down' fashion, where the researcher brings a particular theoretical lens to bear on the analysis being conducted (Crabtree & Miller, 1999). Although TA is often critiqued for the absence of effective guidance for more advanced level, interpretative analysis (Braun & Clarke, 2013), I combined the 'top-down' deductive and 'bottom-up' inductive approaches when I analysed the data in order to capture the underlying complexity. To enhance interpretability, I consciously linked participants' narratives with their particular socio-cultural contexts. My conceptual framework and the patterns found in the quantitative data together constitute the deductive framework, while I also inductively discovered other key ideas from the qualitative data collected.

I conducted TA based on the following systematic six phases (ibid):

1) Familiarizing Yourself with the Data
2) Generating Initial Codes
3) Searching for Themes
4) Reviewing Themes
5) Defining and Naming Themes
6) Producing the Report

The first and second steps of analysis started as early as when I was conducting the interviews and converting the interview data into organized manuscripts. I used an auto-tool to transcribe the recording (Hopper et al., 2021), but as suggested by Braun and Clarke (2006), to engage myself in the depth and breadth of the corpus, I listened to the recordings again to check the accuracy of the auto-transcriptions and I also noted down a number of important points and initial analytical thoughts triggered by each of the interview. The analysis of transcripts was initially completed using Microsoft Word, as I assumed that constant revisions on codes would be made as I finished more interviews and analysed more data. Thus, Microsoft Word would be more convenient to make those revisions. After analysing eight transcripts (1/3 of the total number), I started to move everything into NVivo – rereading the narratives, coding at appropriate places, generating themes, etc. Mind-maps on codes and themes were drawn to manage the hierarchical logics in a more visualized approach.

Three overall organisational groupings of emerging themes were identified which are closely associated with the last three research questions: motivations to learn engineering at university; being female engineering undergraduates at Chinese universities; and career choice process of female engineering students. The arrangement of qualitative Chapters 7, 8 and 9 is also based on these themes; science/engineering capital related content is embedded into these chapters. There are also multiple sub-themes under the three main themes, which are generated and analysed based on the interview narratives and the theoretical framework, emphasizing the interaction of agency and social structure concerning gender norms and SES. Besides the themes, I tagged the storyline of each participant with key events affecting their various choices at different educational stages, which provides clear narratives on how an individual gradually grows into the person she is now. With these storylines, I could more effectively connect various previous experiences with career choices when writing the qualitative findings chapters.

5.4 Ethical considerations

The ata collection process strictly aligned with the British Educational Research Association (BERA, 2018) ethical guidelines and UCL IOE's ethical approval process. An ethical and confidential approach was assured to obtain access to all participants. Only fully anonymised data were kept in electronic form in UCL OneDrive and my personal encrypted laptop. Original audio recordings were securely deleted once I had verified transcription accuracy. All the data collected were used for academic research only. The interview participants and most survey participants were over the age of 18. Survey participants who were under 18 in particular were suggested on the introduction page of the questionnaire to discuss participation with their parents/guardian. More importantly, as an independent researcher, I was aware of self-reflexivity and reflected on how I, as a female Chinese, a feminist and a non-engineering major, affected the research design, the data collection, and data analysis.

5.4.1 Voluntariness and freedom

Participants took part in the survey and the semi-structured interviews on a voluntary basis, with the acknowledgment that invisible power relations may exist when faculty staff helped me distribute the survey to their students. As Covid-19 restricted the fieldwork research, and face-to-face interviews were preferred, I followed the updated rules of UCL as well as the permission of Chinese universities and the participants. Interviews were not conducted in any dangerous or remote places to ensure the safety of both interviewees and the interviewer. Online interviews were conducted via Zoom. The face-to-face interview was conducted in a quiet café near the participant's university. The consent form, information sheet and interview schedule were sent electronically to interview participants. Interviewees were clearly informed that the interviews would be audio-recorded electronically, but they could ask for a stop whenever they wished and they could refuse to answer any questions. Particularly, as my research concerns SES, which may be regarded as a sensitive topic, participants were informed in advance that they were completely free to withdraw if they felt uneasy talking about the financial status of their family and any other issues that might make them uncomfortable. Fortunately, all participants were open to talking about their family backgrounds.

5.4.2 Confidentiality

The survey was carried out using Online Surveys, a UCL-approved secure survey tool, on an anonymous basis, except for some final year female students who were interested in participating in an interview, as they were asked to share their contacts. Everyone taking part in the interviews were anonymised by giving each a pseudonym, and each setting they mentioned was replaced by vague words such as 'my university' and 'my company'. The survey results, the recording and the transcript of each interview were under encipherment protection only for use in this project. During the valid time of the data, only I had access to the original raw data and only my supervisors could see anonymised data where needed. The recordings were deleted after I finished each transcription.

5.4.3 Self-reflexivity of the researcher

From the perspective of interpretivists, research is co-produced by participants and the researcher (Koro-Ljungberg & Douglas, 2008). In this study, I mostly positioned myself as a 'semi-insider', since I am a Chinese, more specifically a Shandong woman, but not an engineering learner at university. My demographic backgrounds, including marginalized or privileged subjectivities (Ramanathan, 2005; Secules et al., 2021) and personal experiences (Bryman, 2012), tend to unavoidably have some impacts on this study, in terms of aspects ranging from the research topic, ontology and epistemology, the formulation of survey and interview questions, data collection, data analysis, to the final presentation of research findings (Secules et al., 2021; Xu, 2018). Presenting the positionality of the researcher transparently, as a measure to prevent potential bias, is essential for equitable research.

With the same gender, ethnicity and even the same hometown, my interview participants and I tended to be placed in a relatively equal position, and this may have promoted a sound level of trustworthiness. Establishing a close rapport with participants can assist researchers in gaining a deeper understanding of the research context and amplify richness in the data (Godwin et al., 2021; Ulin, Robinson & Tolley, 2004). Though some of my participants were from elite universities (much better than my undergraduate university) and it is recommended to engender unequal power relations during the interview process (Maxwell & Aggleton, 2015; Rice, 2010), my seniority and current education background possibly mediated this effect. For those from less well-regarded universities, to reduce the power effect from my side, I usually told them I got my bachelor's degree from the same type of university as them. Another point worth mentioning is that some participants (N=4) chose to take part in the interview because they wanted to pursue a doctorate programme as I was, meaning that they wanted to get useful information from me. In this case, they might have intentionally talked about their experiences in a way that they assumed I wanted to hear.

As I have never systematically learnt engineering at university, I lack knowledge of professional engineering terms and the real-world engineering learning and job-seeking environment. Being aware of this, I first tried to absorb relevant information, such as online resources and academic literature, especially when I designed the survey as I noted above. I also talked with my friends who learned engineering subjects to arm myself with some knowledge and information in this domain. During the interviews, I politely asked participants to explain any technical words that I did not understand. When analysing and presenting the quantitative and qualitative data, my non-engineering background might have helped in 'distancing' me from the data, and I consciously tried to avoid being affected by my preconceptions. Instead, I drew conclusions from the data at hand with reference to the existing literature.

Besides the qualitative data collection, as I did not get to meet with most of my survey participants face-to-face and it was conducted in an anonymous and online basis, my background is deemed to have had a limited effect on the survey data collection.

5.5 Limitations

This section primarily discusses the limitations related to the methodology of this study, while Section 10.6 will address additional limitations concerning the overall research.

In terms of data collecting and sampling, four major limitations were identified. First, pre-defined items and options in the survey may have limited the capture of data that were expected to be specific to Chinese contexts, but the following interviews could help to further explore how specific Chinese contexts affected their experiences and career choices. For example, as noted above, inspired by the cognitive interview, I replaced 'science (科学)' with 'science and/or engineering subjects (理工科)'. This may have narrowed participants' understanding of the original word ‘science’. To further capture their ideas of ‘science’, I asked a question at the end of the semi-structured interview: ‘What is ‘science’ in your opinion?’ There were very different understandings and subject boundaries to ‘science’, which in turn further justifies my revision of the translation.

Second, it was difficult to recruit interview participants whose career decisions were completely outside engineering, such as those pursuing careers as language teachers. This may be because this group is small to begin with. Since people often leverage their acquired knowledge when seeking jobs, the majority of those who chose careers outside engineering still tended to find positions related to engineering, though not in technical or professional roles. Additionally, when I asked my existing interview participants to contact classmates who had chosen careers completely outside engineering, all declined. One participant explained that her friend viewed this choice as an embarrassing failure and did not want to discuss it. Due to limitations in my personal resources, I was unable to recruit the expected participants. As a result, my conclusions may overlook the experiences and perspectives of these individuals, which could be explored in future research

Third, the gathered data may be subject to bias. All the data collected were self-reported, rather than factual. Since they were based on what participants told me, it was beyond my control as to whether these data are true or not. In addition, as mentioned previously, the self-selection mode of the participant recruitment process may have led to the result that students who had a higher interest and inclination of working inside engineering were more likely to agree to participate in the study.

Fourth, this research produces conclusions mainly based on the qualitative results with a small sample of 24 participants, with the acknowledgement as a limitation of the sample that they cannot be generalized to the whole population. Instead, this study attempts to explore the complexity of how gender and SES play intersectional roles in shaping subject and career choices among Chinese female engineering students. Meanwhile, the quantitative data provides a relatively larger landscape of the statistical distribution of gender and SES among engineering undergraduates in terms of their experiences and career aspirations, though only from Shandong province, contributing to the limited database in this regard in China. Future research is suggested to cover more geographic areas in China.

When it comes to the processing of data analysis, there are two limitations, and Chapter 6 will provide more details. One possible limitation lies in the data clearance of survey data. To increase validity and correlations of the data, I removed 39 cases who were defined as very fast responders, with the acknowledgement that this movement may lead to an omission of some worthy answers and may result in ethical risks of not valuing data collected. This will be explained in more details in the next chapter. Furthermore, 24 survey responses from individuals who did not identify as either men or women were excluded from the analysis. This exclusion is acknowledged as a limitation, as the analysis focuses on a binary categorization of gender, without considering non-binary identities.

Additionally, categorizing a career outside and inside engineering can possibly create a binary trap. In the survey, I offered five options of career plan: 1) Engineering researcher at university/research institutes; 2) Engineering teacher at school; 3) An engineer at enterprise; 4) The non-specialized department of engineering enterprise, such as sales or marketing department; and 5) Other, please specify. When calculating the percentage of being inside or outside engineering, options 1) and 3) were regarded as continuing with engineering; options 2) and 4) were counted as being leaving engineering; while the answers in options 5) were manually categorized into each group (Section 6.5.1). However, as I discussed with my interviewees their career aspirations and/or choices, I found that they had quite different and individualized criteria about the categorization of being inside or outside engineering and the two directions could even overlap. In other words, simply defining a choice of being inside or outside engineering may not fully cover the diversity of available career plans.

Similarly, as I argued in my conceptual framework, binary thinking, such as agency and structure, femininity and masculinity, can be problematic. Instead, they are integrated with each other in a fluid and dynamic manner. During the interviews, I thus invited my participants to define their choices of being inside or outside engineering themselves, rather than using a standard, fixed criterion. In this case, having a non-binary construction of being inside and outside of engineering implies that similar job positions can be placed in different category by different participants.

5.6 Summary

This chapter illustrated the design and implementation of the research methodology, and elucidated the relevant justifications for these choices. A clear stance as an interpretivist rather than a positivist, using a mixed-methods approach, was first described. Then, the detailed fieldwork process from the design of instruments to data collection and data analysis was provided. I can thus draw a more comprehensive picture of how gender and SES affect the shaping of female Chinese engineering students' experiences and career choices. I then discussed ethical concerns touched upon in this research, including confidentiality, voluntariness and freedom. My positionality as a 'semi-insider' was also rigorously reflected as a potential impact factor on data collection and data analysis. Finally, a series of methodological limitations was acknowledged.

Before I present the qualitative findings, the next chapter presents a separate depiction of the descriptive landscape that contextualizes the qualitative elements, by breaking down the quantitative results by gender and SES.

Chapter 6 Quantitative data analysis

This chapter presents a descriptive statistical analysis of how gender and SES affect the experiences, perceptions and career choices of the sample of Chinese engineering undergraduates. The survey gathers data on participants' demographics, science and engineering related experience and beliefs before university, subjective beliefs about engineering, university experience and career aspirations. From an interpretivist perspective, the purpose of employing survey techniques is to gain insight into prevailing discourses and landscapes that contextualize the qualitative elements, rather than to make generalizations (McChesney & Aldridge, 2019). Therefore, a predominantly descriptive analysis was conducted to summarize the sample. Additionally, surveys can yield novel statistical data, particularly regarding SES, which, to the best of my knowledge, is scarce in the existing body of Chinese academic literature on engineering education.

This chapter begins with how the data were cleansed and analysed. Afterwards, demographic statistics are presented, which can also help to verify the diversity and representativeness of the sample. After that is a section dedicated to reporting and analysing 'the adapted science capital index' within the context of my study, particularly concerning undergraduate students in the field of engineering in China. Subsequently, the survey data are analysed by gender and SES in more detail. Finally, the findings derived from the analysis of open-ended questions are discussed.

6.1 Data cleansing

There were two primary purposes of the data cleansing phase: 1) to ensure that my final sample was relevant to the study by considering participants' majors and participants' behaviours and determining the final size of the sample (N=532); and 2) to check for missing data and code and recoding data for statistical analysis.

In total, I collected 607 survey responses through personal contacts at universities together with a snowball sampling approach. The survey was distributed to both male and female engineering undergraduates in their first to final years at as many universities in Shandong province as were accessible. Details of the instrument design and data collection process were described in Chapter 5. To ensure the eligibility of the responses, I checked for two main criteria: engineering-related subjects and non-automatic response patterns.

I first checked participants' field of study – whether they were studying engineering-related subjects, by reviewing their responses to an open-ended question where they stated the name of their undergraduate programme. Of the initial 607 responses, only 571 were from participants studying engineering-related subjects.

I then conducted preliminary analyses which unveiled noteworthy observations. Specifically, it was observed that a subset of students provided identical responses to the survey questions. To gain further insights, I examined their response times and discovered a trend of prompt and expeditious responses among these individuals. Given that the way I approached some respondents was through their tutors/lecturers, they probably felt obligated to complete it but not necessarily interested. When survey participants are unfairly mainly motivated to complete a survey, instead of providing responsible and careful answers, a rapid response rate is recorded (Zhang & Conrad, 2014). It is normal to have speed differences between people, so rapidity here does not refer to quicker responses but to extremely fast responses when responses are selected arbitrarily without reading the question. These responses are hence of little importance to the research. Therefore, completion time can be a possible indicator of data quality (Malhotra, 2008). Although removing these responses does not seem not to change marginal distributions, it can increase correlations (Greszki, Meyer & Schoen, 2015).

Another common type of invalid case could be called 'straight-liners'. As scales with items in my survey were worded in the same direction, it was difficult to identify the genuine response patterns in cases with a 'straight-line' character (Melipillán, 2019). For example, strongly agreeing with all the items could genuinely accord with their real thoughts. Also, research has shown that Asians are more likely to choose the midpoints rather than extreme responses on Likert scales (Wang et al., 2008). Therefore, I was reluctant to remove all straight-liners, particularly those who spent a reasonable amount of time completing the survey. Meanwhile, as Zhang and Conrad (2014) remind us, ‘speedy’ respondents are also prone to a ‘straight-line’ approach. This suggests that excluding responses based solely on speed may be the safest approach.

To identify rapid responders, I used a criterion based on response time, defining them as those who completed the survey 50% faster than the median time (Greszki, Meyer & Schoen, 2015). It is necessary to adopt the median to analyse the response time, on account of the positively skewed distribution of response time (Ratcliff, 1993; van Zandt, 2002). The median time used by the 571 responses to complete my survey was 6 minutes and 29 seconds, and 50% of this is 3 minutes and 14.5 seconds. Based on this criterion, another 39 cases (6.8%) were removed, resulting in a remaining sample of 532 survey responses. A potential limitation of the research lies in losing participant responses, which could have a possible impact on the comprehensiveness of the findings.

For statistical analysis, I conducted several treatments on the data format within the 532 cases. I addressed a very limited amount of missing data by assigning a value of 999. Data preparation tasks, including translation, labelling variables, grouping variables, coding and recoding variables, were conducted using Excel and SPSS.

6.2 Data analysis techniques

Before starting data analysis and running any kind of statistical tests, I checked the characteristics of the data. First, I explored the data distribution to determine the most appropriate statistical analyses to use – parametric tests (if data is normally distributed) or non-parametric tests (not normally distributed). SPSS results show that items measuring ‘science and engineering related experiences and beliefs before university’, ‘subjective beliefs in engineering', 'university experiences' and 'career aspirations' for men and women, rural respondents and urban respondents, as well as parents with and without a higher education degree have skewness and kurtosis values between -2 to +2. As my sample size was much larger than 300, the data can be considered approximately normally distributed (Kim, 2013; Kline, 2015). The visual inspection of their histograms, normal Q-Q plots and box plots also showed that the data were approximately normally distributed. I therefore adopted parametric tests in my analysis.

Two main statistical techniques were used to analyse the quantitative data: Crosstabs with Pearson's chi-square test and Independent-samples t-test. Data characteristics regarding frequencies and percentages, means, and standard deviations (SDs) were also recorded and analysed. Chapter 5 provided an overview of the different types of survey data. For categorical variables, I analysed the number of things that fell into each combination of categories (i.e., the frequencies and percentages) and Crosstabs were used to compare those frequencies and percentages. Pearson's chi-square test was performed to see whether there was an association between two categorical variables (Fisher, 1922; Pearson, 1900). For numeric variables, means, SDs and p-values were calculated and reported. An Independent-samples t-test was performed to compare two means from conditions consisting of different entities (Field, 2018). For reporting purposes, the level for statistical significance was set at 0.05. At the end of this chapter, I explain how I analysed the written answers to open-ended questions using statistical methods (Crosstabs and Chi-square) as well as content analysis (frequencies of themes).

6.3 Demographics

This section provides a brief overview of the demographic variables in the survey, including gender, type of university attended, year of study, family location and parental educational backgrounds. It also assists with understanding the diversity of the respondents, though an exception of an homogeneous element identified in terms of parental education backgrounds due to the specific national context.

6.3.1 Gender

As illustrated in the last section, I collected 532 valid responses, among which only 508 participants clearly indicated their gender as being a man or woman. Among the other 24 respondents 19 chose ‘prefer not to say’; since my research focuses on gender, those who chose ‘prefer not to say’ would not be helpful in this regard. Only five respondents chose ‘other’, a very small number that is difficult to engage with quantitatively. Moreover, I did not ask for more details after the option ‘other’ because it is politically sensitive to ask non-binary gender identity information in China where people tend to be socially pressured to talk about it (Häyrynen, 2020). Therefore, although I appreciate the fluidity of gender and respect each response, I disregarded these five responses and considered the 508 male and female responses to analyse how gender makes a difference in engineering students’ experiences and career decisions. It has been acknowledged as a limitation that my analysis is focused on this binary categorization of gender, without considering non-binary gender identities.

Among the 508 engineering responses, 31.1% were women (N=158) and 68.9% were men (N=350). This is close to the result of the national survey on profiles and career prospects of recent graduates in all undergraduate programmes in China carried out by Wutongguo (2018), which found there were 2.3 times as many men engineering graduates as women.

6.3.2 Types of university and year of study

It is noted that the categorization of universities is based on the overall competitiveness of all programmes at universities related to national rankings, rather than on merely the ranking of engineering degrees. Universities listed in ‘Project 985’ and ‘Project 211’ are regarded as the most renowned high-level universities in China (Jiang, Lee & Rah, 2020). ‘Project 985’ and ‘Project 211’ are initiatives launched by the Chinese government to build world-class higher education institutes, by devoting more funding and resources to improve the research and teaching competitiveness of selected top universities in China. ‘Project 985’ and ‘Project 211’ refer to the best universities in the first tier, which includes many other non-985/211 universities. First-tier universities are generally more academically prestigious compared to second- and third-tier institutions in China. An ordinary engineering undergraduate programme at Chinese universities lasts four years. Figures 6-1and 6-2 show that participants were from various types of universities and diverse years of study, although with a higher representation of second tier (non-985/211) and first tier university students, and with a majority of respondents studying in years one and four. This may reduce the overall generalisability, but it is not the aim of this study to generalize the results to the wider population.

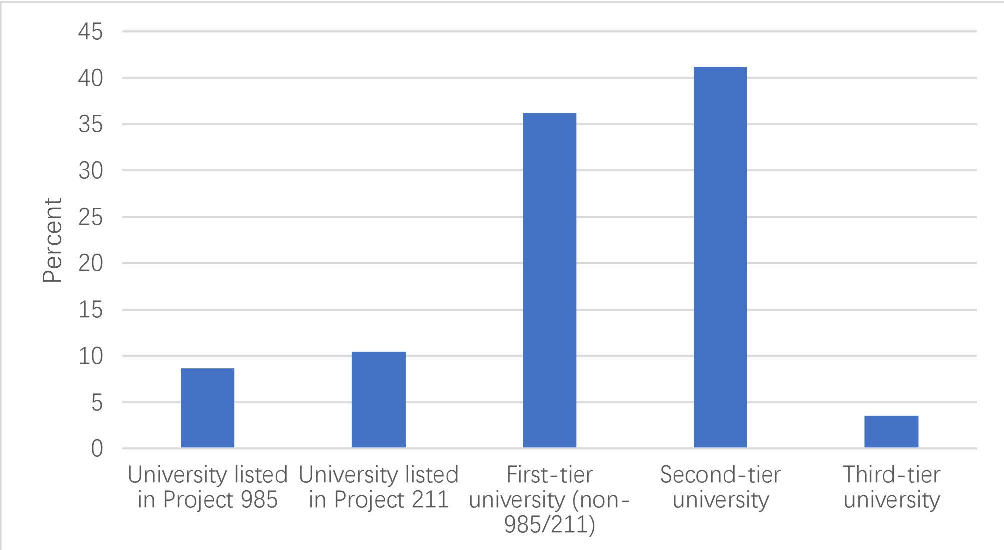

Figure 6-1 Type of university attended

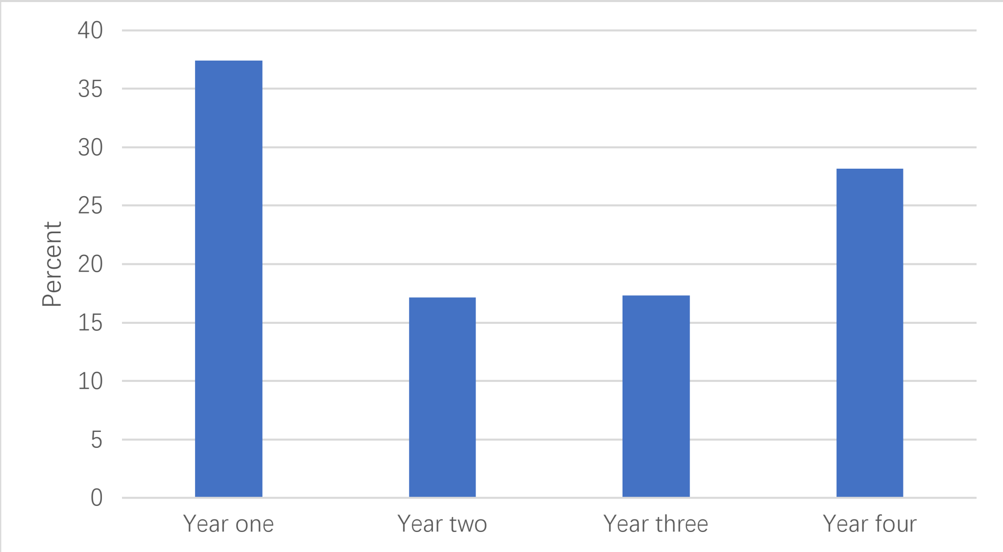

Figure 6-2 Year of study

6.3.3 Family backgrounds

Questions about family backgrounds in the survey include family location and parental educational backgrounds. Around half of the respondents were from urban areas (52.6%, N=267) and half from rural areas (47.4%, N=241). The comparable distribution of rural and urban areas indicates diversity in the sample. There were 10.8% participants (N=55) who had a father with a higher education degree, while only 5.9% respondents (N=30) had a mother with such a degree. Most parents of the sample had not received higher education. The year 1999 marked the expansion of higher education in China (Yue, 2018), long after most of these parents would have reached university education age. Supporting this, the gross rate of higher education participation in China was only 6% in 1998 (ibid). Therefore, though parental education backgrounds in the sample appear homogenous, they can be considered representative due to the specific Chinese context.

6.4 Adapted science capital index

As elaborated in Chapter 5, I adapted Archer's science capital index into the context of my research based on the cognitive interview results. I made adjustments such as translating 'science' into 'science and engineering subjects' in Chinese, adding a new option of frequency of 'once every few years', as well as replacing 'GCSEs' with 'subject divisions from year 2 at high school.' Bearing all the adaptations in mind, when analysing the data, I consciously made the weightings in my version comparable with those in the original index.

Following the grouping approach used by Archer and colleagues (2015), respondents' science capital scores were transformed onto a scale of 0-105 and this distribution was then employed to categorize students into three groups: low (0-34), medium (35-69), and high (70-105) levels of science capital. In my study, based on my adapted science capital index, possessing high science and engineering capital indicates a strong level of scientific and engineering literacy and access to plentiful, high quality, science and engineering-related cultural, and social resources.

Figure 6-3 shows the percentages each category accounts for among the engineering undergraduates participating in the study. Most of my sample (61%) is classified as holding medium levels of science capital. The percentages for those with low science capital and high science capital are respectively 29% and 10%. Compared with the distribution of science capital scores among secondary school students aged 11-15 years in England (Archer et al., 2015), the most obvious difference is that the percentage of students holding high level of science capital doubles, from 5% in their cohort to 10% in my sample. This can be ascribed to the fact that my sample group had been engaged in engineering at university, so they were more likely to possess higher levels of science capital.

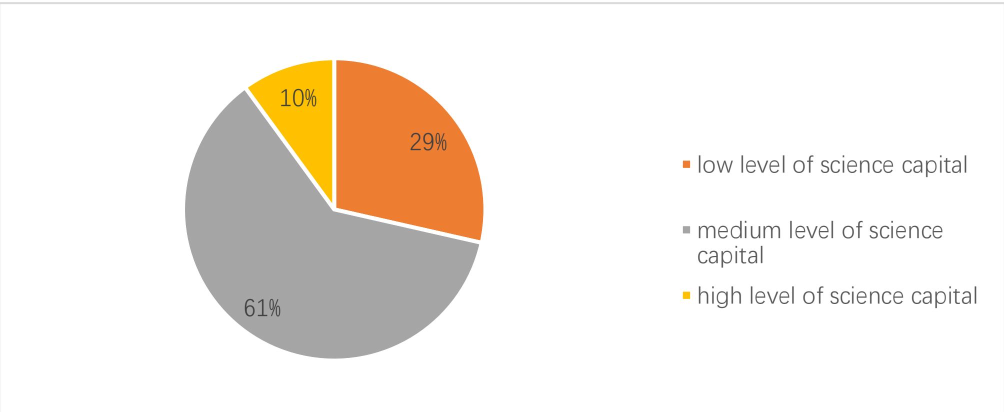

Figure 6-3 Distribution of science capital scores

Regarding how science capital index is patterned by social characteristics, Archer and colleagues (2015) conclude that students from socially privileged communities, such as white men with higher cultural capital, are often more exposed to science capital. My study concerns gender, cultural capital and family geographical location (rural-urban) as social characteristics that affect the volume of science capital held by engineering undergraduates.

Surprisingly, there is no significant gender difference between men and women engineering students in my sample regarding their science capital scores, as the independent sample t-test results suggest that women and men students share similar means for science capital scores, with a slightly higher average score of women ($M=45.71$, $SD=19.63$) than men ($M=45.01$, $SD=16.27$), $t(506)=-.406$, $p=.663$.

Respondents from urban areas ($N=267$, $M=47.04$, $SD=19.30$) possess a higher level of science capital than rural students ($N=241$, $M=43.24$, $SD=17.70$), and this difference is statistically significant: $t(506)=2.307$, $p<0.05$. When it comes to parents' highest educational level (to measure cultural capital), students with a father obtaining a higher education degree ($N=55$, $M=49.60$, $SD=18.96$) reported a higher science capital score than students whose fathers had never received higher education ($N=435$, $M=44.87$, $SD=18.69$), $t(488)=1.776$, $p<0.05$. However, in my sample, a mother's educational level did not have a significant effect on the volume of science capital a Chinese engineering undergraduate holds, $t(487)=.639$, $p=.523$, though students who had a mother with a higher education degree reported a higher average score ($N=30$, $M=47.51$, $SD=20.30$) than those without ($N=459$, $M=45.25$, $SD=18.65$). Therefore, these patterns suggest that my sample of engineering students at university, who live in urban areas and have a father with a higher education degree, tend to possess a higher level of science capital.

Similar to other findings that pre-university students possessing higher levels of science capital tend to have stronger science and engineering aspirations (see Archer et al., 2015; DeWitt et al., 2016; Moote et al., 2019b; Moote et al., 2020), the t-test results for my sample show that there is a significant difference in science capital volume one holds between different career aspirations of being inside (N=287, M=47.58, SD=19.47) and outside engineering (N=98, M=42.81, SD=17.74), t(383)=2.145, p<.05. In this case, science capital appears to be closely aligned with engineering students' career aspirations, meaning that students with higher science capital scores are more likely to pursue an engineering-related career than those with lower science capital scores.

The above analysis is based on both men and women engineering students to describe an overall picture, but as the follow-up qualitative interviews only focused on women, it would be helpful to consider how the science capital index is distributed among women respondents (N=156) when comparing their family geographical backgrounds (rural-urban) and career aspirations. T-test results show that urban women respondents (N=83, M=49.77, SD=17.47) tend to have significantly higher science capital score than their rural counterparts (N=75, M=41.27, SD=13.61), t(156)=3.385, p<0.01. Parental educational backgrounds will not be analysed here due to the small sample size and detailed justifications found in Section 6.6.1. Therefore, among women engineering students in my sample, those who live in urban areas tend to possess higher levels of science capital. Furthermore, t-test results suggest that there is no statistically significant difference in science capital levels of women with career aspirations to be inside (N=74, M=48.38, SD=16.79) or outside engineering (N=41, M=45.48, SD=13.15), t(113)=.953, p=.31. This may reflect the limitation of the quantitative analysis combining various aspects of capital into a single science capital index, but the following qualitative phase of the study, including interviews, can help to explain which aspects of science capital take effect in this process against Chinese contexts and female engineering students, and how those factors make a difference. Hence, in the interview schedule, distinct questions were asked regarding science-related social capital and cultural capital to ensure a comprehensive exploration of these aspects.

6.5 Gender comparisons

In this section, independent-samples t-tests were performed to compare how men and women engineering undergraduates in the sample reported on career aspirations, experiences and perceptions towards engineering.

6.5.1 Career aspirations

Considering the increasing trend of Chinese undergraduates choosing to continue with a master's programme after graduation due to 'educational inflation' (where, due to the extension of higher education participation in China, a bachelor's degree is not as valued as before), I designed the survey to first ask 'whether you plan to continue your further studies in engineering (e.g. master's; PhD)' first, and then asked about their career aspirations separately. This was a user-friendly way to ask questions as participants could more easily follow the logic of the survey, although it required the creation of a new variable for data analysis. A new variable named 'final career plan' was created using SPSS based on respondents' answers to the abovementioned questions. This new variable was coded with four values to represent respondents' career aspirations of being inside or outside engineering:

1. **Inside engineering**: Engineering researcher at university/research institutes; An engineer at enterprise; Explicit open-ended answers under the option 'other, please specify' in the survey that can be categorized into inside engineering, such as 'professional jobs related to my field of study'.
2. **Outside engineering:** Teacher at school; Non-specialized department of an engineering enterprise, such as sales or marketing department; Explicit open-ended answers under the option 'other, please specify' that can be categorized into inside engineering, such as 'photographer' ; Those who will continue their study in a different

subject (I should have asked about their career plan, but I automatically assumed they would work outside engineering, which is acknowledged as a limitation of this study).

3. **Unclear:** No answer/missing data; Short and obscure open-ended answers under the option 'other, please specify' that cannot be simply categorized into inside or outside engineering by myself, such as 'start my own business' and 'join the army'.
4. **Not sure:** Those who were not sure or had never thought about their career plans.

When it comes to final career aspirations of being inside or outside engineering, there were significant differences between women and men in my sample, X^2 (3, N = 508) = 11.829, $p<.05$. Specifically, 60.9% of men planned to pursue a professional position within engineering, compared to only 46.8% of women students. This is in line with the mainstream findings among research on the representation issue in STEM fields that larger proportions of men transfer into STEM workplaces than women (Jan & Sean, 2012). The results are shown in Table 6-1. Meanwhile, there was a higher proportion of women students (20.9%) who did not have an explicit career plan than men (14.9%), indicating a more urgent need for career guidance targeting women engineering undergraduates in China.

			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%

Table 6-1 Crosstabulation: Final career plan *Gender

Remembering the 'educational inflation' in China, I also note how women and men students have different plans to further their study or enter the job market. Table 6-2 suggests that a higher percentage of men engineering students (70.9%) choose to pursue a master's degree than women (62%), though this difference is not statistically significant, X^2 (3, N = 508) = 7.159, p =.067. Participants' graduation plans were further explored during the interviews, and the results are presented in Chapter 9.

			Further study	Work	Not sure	Never think about it	Total
Gender	Men	Count	248	50	44	8	350
		% within Gender	70.9%	14.3%	12.6%	2.3%	100.0%
	Women	Count	98	27	23	10	158
		% within Gender	62.0%	17.1%	14.6%	6.3%	100.0%
Total		Count	346	77	67	18	508
		% within Gender	68.1%	15.2%	13.2%	3.5%	100.0%

Table 6-2 Crosstabulation: Graduation plan * Gender

6.5.2 First choice of subject to learn at university

Students' first choice of subject to learn at university refers to what they most desired to study – several have to study subjects they have no interest in due to the 'tiaoji' system, introduced in Section 1.4. Table 6-3 presents the number and percentages of men and women engineering undergraduates in the sample, based on their first-choice subject when filling out the 'Gaokao' application form. There were 40.5% women, compared with 26.3% men, whose first choice was not engineering-related subjects, X^2 (1, N = 318) =13.98, p <.001. This means that there are differences between men and women in their initial subject choice preferences, even if they are all eventually enrolled in an engineering programme. In this regard, a lack of motivation to study an engineering programme, coupled with an unwillingness from day one, may lead to them leaving engineering in the future.

		Current engineering subject	Other engineering-related subjects	Non-engineering subjects	Total
Gender	Men	131	127	92	350
		37.4%	36.3%	26.3%	100.0%
	Women	59	35	64	158
		37.3%	22.2%	40.5%	100.0%
Total		190	162	156	508
		37.4%	31.9%	30.7%	100.0%

Table 6-3 Crosstabulation: First choice of subject to learn when student filled in the application form * Gender

6.5.3 Family backgrounds

Crosstabulation of urban/rural areas and gender (Table 6-4) shows that among participants, the percentages of men and women from urban and rural areas were fairly similar. This is different from the data of Guo and colleagues (2010) who found that in China, the gap between the number of men (80.1%) and women (19.9%) among engineering undergraduates from rural backgrounds was 60.2%, compared with 51.3% among urban undergraduates in 2005. Compared to my data, there is an increasing trend of women from both rural and urban areas choosing engineering subjects after near 20 years.

			Urban area	Rural area	Total
Gender	Men	Count	184	166	350
		% within Gender	52.6%	47.4%	100.0%
	Women	Count	83	75	158
		% within Gender	52.5%	47.5%	100.0%
Total		Count	267	241	508
		% within Gender	52.6%	47.4%	100.0%

Table 6-4 Crosstabulation: Urban or rural area * Gender

In regard to parental educational background, female participants present a slightly higher possibility of having a well-educated mother and father than men (though not statistically significant). In Tables 6-5 and 6-6, the percentage of women respondents who have a father (or other men primary carer) with a higher education degree (13.3%) is 3.6 percentage points higher than that their men counterparts (9.7%), X^2 (3, N = 508) =2.469, p=.481(though not statistically significant). The gap for mother (or other women primary carer) is 0.6 percentage points, X^2 (3, N = 508) =.88, p=.83 (though not statistically significant as well). This possibly indicates an influence of family cultural capital to men and women students' choice of learning engineering. Again, the interview results can provide further explanations on this point.

			Higher education degree	Non-higher education degree	Don't know	Single parent	Total
Gender	Men	Count	34	303	7	6	350
		% within Gender	9.7%	86.6%	2.0%	1.7%	100.0%
	Women	Count	21	132	4	1	158
		% within Gender	13.3%	83.5%	2.5%	0.6%	100.0%
Total		Count	55	435	11	7	508
		% within Gender	10.8%	85.6%	2.2%	1.4%	100.0%

Table 6-5 Crosstabulation: Father's (or other man primary carer) highest education level * Gender

			Higher education degree	Non-higher education degree	Don't know	Single parent	Total
Gender	Men	Count	20	317	11	2	350
		% within Gender	5.7%	90.6%	3.1%	0.6%	100.0%
	Women	Count	10	142	4	2	158
		% within Gender	6.3%	89.9%	2.5%	1.3%	100.0%
Total		Count	30	459	15	4	508
		% within Gender	5.9%	90.4%	3.0%	0.8%	100.0%

Table 6-6 Crosstabulation: Mother's (or other woman primary carer) highest education level* Gender

Parents' field of study and work does not just reflect students' possession of engineering social capital, but also suggests a gendered picture in engineering among the parents' generation. Tables 6-7 and 6-8 suggest that there were 26% fathers working inside engineering field, more than three times as many as the proportion of mothers (7.7%). Tables 6-9 and 6-10 suggest that there were 41.3% fathers who studied in an engineering field, nearly twice as many as the proportion of mothers (22.5%). This can reflect gender stereotyped job preferences among the parents' generation, which might be reflected in their child-rearing. The percentage of fathers not in employment was only 5.9%, while mothers totalled 18.9% (retirement is excluded because respondents were reminded to refer to the work their parents did before retirement). This is in line with the traditional Chinese family structure that men are breadwinners and women take care of domestic issues. Breaking the picture down in gender, Table 6-9 suggests a marginally higher percentage of men respondents who had a mother and father who worked in and studied engineering (though not statistically significant):

- Father's job, X^2 (3, N = 508) =7.421, p=.06: Men 28.6%; Women 20.3%
- Mother's job, X^2 (3, N = 508) =6.917, p=.075: Men 9.7%; Women 3.2%
- Father's field of study, X^2 (1, N = 104) =.137, p=.711: Men 42.6%; Women 38.9%
- Mother's field of study, X^2 (2, N = 80) =.059, p=.971: Men 23.1%; Women 21.4%

			Engineering-related	Non-engineering-related	Not in employment	Single parent	Total
Gender	Men	Count	100	219	22	9	350
		% within Gender	28.6%	62.6%	6.3%	2.6%	100.0%
	Women	Count	32	117	8	1	158
		% within Gender	20.3%	74.1%	5.1%	0.6%	100.0%
Total		Count	132	336	30	10	508
		% within Gender	26.0%	66.1%	5.9%	2.0%	100.0%

Table 6-7 Crosstabulation: Father's (or other man primary carer) job* Gender

			Engineering-related	Non-engineering-related	Not in employment	Single parent	Total
Gender	Men	Count	34	245	67	4	350
		% within Gender	9.7%	70.0%	19.1%	1.1%	100.0%
	Women	Count	5	122	29	2	158
		% within Gender	3.2%	77.2%	18.4%	1.3%	100.0%
Total		Count	39	367	96	6	508
		% within Gender	7.7%	72.2%	18.9%	1.2%	100.0%

Table 6-8 Crosstabulation: Mother's (or other woman primary carer) job* Gender

			Engineering subjects	Non-engineering subjects	Total
Gender	Men	Count	29	39	68
		% within Gender	42.6%	57.4%	100.0%
	Women	Count	14	22	36
		% within Gender	38.9%	61.1%	100.0%
Total		Count	43	61	104
		% within Gender	41.3%	58.7%	100.0%

Table 6-9 Crosstabulation: Father's (or other man primary carer) field of study for their highest qualification* Gender

			Engineering subjects	Non-engineering subjects	Don't know	Total
Gender	Men	Count	12	32	8	52
		% within Gender	23.1%	61.5%	15.4%	100.0%
	Women	Count	6	18	4	28
		% within Gender	21.4%	64.3%	14.3%	100.0%
Total		Count	18	50	12	80
		% within Gender	22.5%	62.5%	15.0%	100.0%

Table 6-10 Crosstabulation: Mother's (or other woman primary carer) field of study for their

highest qualification* Gender

In the survey, I asked questions about siblings and relatives as part of their family background. Tables 6-11 and 6-12 suggest a slightly higher percentage of women in my sample had siblings X^2 (1, N = 508) =.424, p=.515 (men 9.1% ,women,11.4%), and relatives X^2 (1, N = 508) =2.305, p=.580 (men 35.4%, women 38%), working or studying in engineering than their men counterparts, although it is not statistically significant. It is notable that the observed trend regarding siblings and relatives is contrary to the findings concerning the abovementioned parents' professions and educational backgrounds.

			Siblings who work or study in engineering	No siblings who work or study in engineering	Total
Gender	Men	Count	18	179	197
		% within Gender	9.1%	90.9%	100.0%
	Women	Count	14	109	123
		% within Gender	11.4%	88.6%	100.0%
Total		Count	32	288	320
		% within Gender	10.0%	90.0%	100.0%

Table 6-11 Crosstabulation: Area of siblings* Gender

			Relatives who work or study in engineering	No relatives who work or study in engineering	Total
Gender	Men	Count	124	226	350
		% within Gender	35.4%	64.6%	100.0%
	Women	Count	60	98	158
		% within Gender	38.0%	62.0%	100.0%
Total		Count	184	324	508
		% within Gender	36.2%	63.8%	100.0%

Table 6-12 Crosstabulation: Area of relatives* Gender

6.5.4 Engineering agency

Independent-samples t-tests were employed to compare means and standard deviations (SD) of each agency item between men and women. Means and SDs were calculated for respondents' answers on a 5-point Likert scale with 1=Strongly Disagree and 5=Strongly Agree. The interpretation pattern utilized in this section was derived from a study by O'Meara and colleagues (2014), as most of the items measuring engineering agency were adapted from their research. Table 6-13 shows that both men and women engineering students reported a good degree of engineering agency (means between 3.27 and 3.98). Drilling down to gender differences, among those who had already learnt engineering at university, women reported higher average scores than men regarding most of the engineering agency measurements. This suggests that women may need or have already gained higher levels of engineering agency to empower them to resist the stereotyped social structures to learn engineering.

Women students only reported slightly lower scores than their men counterparts in four items and only N12 had a statistically significant lower score: 'N7: My parents/relatives/ friends see me as an engineering person', $t(506)=1.453$, $p=.147$, 'N8: I am interested in learning more about engineering', $t(506)=.229$, $p=.819$, 'N9: I believe I can understand concepts I have studied in engineering', $t(506)=.871$, $p=.384$, 'N12: My personal abilities/talents 'fit' the requirements in engineering', $t(506)=2.028$, $p<.05$, in line with existing findings suggesting that such women tend to have lower interest and confidence in learning engineering, as well as weaker engineering subjectivities (Guo et al., 2015; Vogt, Hocevar & Hagedorn, 2007). These elements may play a role in their career choices.

Engineering agency items	Men Mean (SD)	Women Mean (SD)	P-value	Cohen's d
1. I believe learning engineering will improve my career prospects	3.63 (1.075)	3.68 (.891)	.638	-.042
2. I believe engineering can help me see opportunities for positive change	3.50 (1.103)	3.60 (.944)	.311	-.092
3. I believe learning engineering can make me more critical in general	3.60 (1.100)	3.76 (.848)	.084	-.151
4. I believe engineering is helpful in my everyday life	3.56 (1.087)	3.70 (.899)	.116	-.141
5. I believe engineering will provide greater opportunities for future generations	3.45 (1.082)	3.64 (.883)	.037	-.186
6. I believe a country needs engineering to become developed	3.86 (1.087)	3.98 (.927)	.198	-.116
7. My parents/ relatives/ friends see me as an engineering person	3.50 (1.051)	3.35 (.965)	.147	.139
8. I am interested in learning more about engineering	3.49 (1.073)	3.47 (1.001)	.819	.022
9. I believe I can understand concepts I have studied in engineering	3.43 (1.068)	3.34 (.976)	.384	.083
10. Others ask me for help in engineering	3.31 (1.082)	3.38 (.968)	.479	-.068
11. I can overcome setbacks in engineering	3.36 (1.060)	3.36 (1.005)	.971	-.003
12. My personal abilities/talents 'fit' the requirements in engineering	3.47 (1.091)	3.27 (.980)	.043	.194
13. I have been strategic in enhancing my engineering capability	3.39 (1.042)	3.52 (.936)	.169	.132

Engineering agency items	Men Mean (SD)	Women Mean (SD)	P-value	Cohen's d
14. I have intentionally made choices to focus on an engineering career	3.47 (1.056)	3.52 (.956)	.608	.049
15. I have seized opportunities when they are presented to me to enhance my engineering capability	3.55 (1.008)	3.64 (.869)	.317	.091
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	.128

Table 6-13 T-test: Engineering agency* Gender

6.5.5 Engineer image stereotypes

Engineering undergraduates in my sample reported relatively low levels of gender stereotypes regarding engineering image and roles, with means ranging from 2.54 to 3.22. Surprisingly, women reported lower average scores than men on all items, though many of the differences were not statistically significant (Table 6-14). Women students had a statistically significant weaker belief that 'N19: engineering is not a job for women' $t(506)=3.147$, $p<.001$ and 'N18: most engineers work with oily machines', $t(506)=2.349$, $p<.05$, than their men counterparts. My findings run counter to some Western research findings that suggest occupational images of the STEM fields are sometimes static and misconceived, especially among women (Perez-Felkner et al., 2012; Chan et al., 2019). Given that Gottfredson (1981) argues that occupational stereotypes can affect the narrowing of choices, a question is thus raised about why Chinese engineering women have less stereotypical views towards engineers, but women still experience larger percentages leaving this field. Again, this constitutes part of the interview schedule and qualitative data can subsequently provide an explanation.

Engineer image items	Men Mean (SD)	Women Mean (SD)	P-value	Cohen's d

17. I believe engineers have to be physically very strong to cope with their work	3.22 (1.073)	3.20 (.976)	.861	.017
18. I believe most engineers work with oily machines	3.06 (1.050)	2.84 (.916)	.019	.225
19. I believe engineering is not a job for women	2.88 (1.121)	2.54 (1.126)	<.001	.302
20. I believe engineering is a dangerous job	2.99 (1.057)	2.89 (.914)	.295	.100
21. I believe engineers are unsociable	2.79 (1.149)	2.63 (1.025)	.129	.146

Table 6-14 T-test: Engineering image stereotypes * Gender

Note: Means and standard deviation were calculated for respondents' answers on a 5-point Likert scale with 1=Strongly Disagree and 5=Strongly Agree. The higher the score, the more stereotyped it is.

6.5.6 University experiences

In the survey, university experiences were examined through questions about academic performance, classroom experiences, after-class engineering activity experiences and internship experiences. Table 6-15 shows higher percentages of women engineering undergraduates than men rating their academic performance among the top 10% and 10%-30% in class. In other words, the sample women (60.2%) tended to report their academic performance as being significantly better than men (45.1%), X^2 (4, N = 508) = 12.187, p<.05. Ignacio and colleagues (2021) found similar results in Spain, indicating that female engineering undergraduates generally achieve either higher or equal academic achievement compared with their male counterparts. It is notable that a higher proportion of women plan to leave engineering even though they tend to have higher grades in engineering courses at university.

			Top 10%	10% ~ 30%	30% ~ 50%	50% ~ 70%	70% ~ 100%	Total
Gender	Men	Count	$68_{a, b}$	90_{b}	94_{a}	63_{a}	35_{a}	350
		% within Gender	19.4%	25.7%	26.9%	18.0%	10.0%	100.0%
	Women	Count	$35_{a, b}$	60_{b}	36_{a}	19_{a}	8_{a}	158
		% within Gender	22.2%	38.0%	22.8%	12.0%	5.1%	100.0%
Total		Count	103	150	130	82	43	508
		% within Gender	20.3%	29.5%	25.6%	16.1%	8.5%	100.0%

Table 6-15 Crosstabulation: How would you rank your current academic performance among other students in your class * Gender

Engineering undergraduates reported a good degree of university classroom experience, with the mean between 3.31 and 3.68 on a 5-point Likert scale. Table 6-16 suggests that women tend to rate their university learning experience higher than men in regard to workload, sense of belonging, classroom climate, group work, teacher-student relationship and role models (though these differences are not statistically significant). This result is different from the 'chilly climate' studies based on Western contexts (Blickenstaff, 2005; Hall & Sandler, 1982; Walton et al., 2015), but it can be in line with and serve to account for the previous claim that those women students tend to report better academic performance than men participants.

University classroom experience items	Men Mean (SD)	Women Mean (SD)	P-value	Cohen's d
22. There is a reasonable workload in the engineering classes	3.48 (1.029)	3.54 (.857)	.508	-.059
23. I have positive and frequent interactions with engineering classmates	3.53 (.977)	3.57 (.832)	.627	-.044
24. There is a fair and inclusive climate in engineering classes	3.63 (.951)	3.68 (792)	.572	-.051
25. I often undertake important tasks in group work	3.40 (1.021)	3.41 (.806)	.925	-.008
26. Teachers are interested in me and confident in my professional ability	3.31 (1.028)	3.35 (.903)	.629	-.046
27. 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	-.108

Table 6-16 T-test: University classroom experience * Gender

Note: Means and standard deviation were calculated for respondent's answers on a 5-point Likert scale with 1=Strongly Disagree and 5=Strongly Agree. The higher the score, the more stereotyped it is.

There was a slightly lower means (though not statistically significant) from women's answers than men’s when it comes to frequency of engineering professional activity involvement, though women tend to claim better academic performance than men (Table 6-17). On-campus engineering professional event involvement may have something to do with the higher rate of leaving engineering as a profession reported by women, since these events are more practice-oriented and they share more similarity with being an engineer than classroom activities.

University after-class engineering activity experience items	**Men Mean (SD)**	**Women Mean (SD)**	**P-value**	**Cohen’s d**
28. Activities held by engineering student clubs, such as Technology-lovers Association, on campus	1.80 (.943)	1.63 (.833)	.051	.146
29. Professional activities or competitions held by the department/ university/nation, e.g. Engineering Drawing Competition	1.73 (.884)	1.63 (.825)	.199	.078
30. Engineering-related undergraduate research experiences, e.g. research seminars，being exchange students as visiting scholar	1.64 (.905)	1.49 (749)	.057	.136

Table 6-17 T-test: University after-class engineering activity experience * Gender

Note: Means and standard deviation were calculated for respondent’s answers on a 4-point Likert scale with 1= Not Involved, 2= 1-2 time/year, 3= 3-5 times/year and 4=More than 5 times/year.

Only 24.6% of engineering students in my sample had an engineering internship (both outside campus and on campus), among whom 19.5% were men and 5.1% women. This may indicate a problem in a Chinese higher education system whereby students lack practical opportunities to apply knowledge learnt in class. Furthermore, the Chi-square test shows that there is a significant gender difference in this regard, X^2 (1, N = 508) = 8.212, $p<.05$: 28.3% men (N=99) claimed that they had an engineering internship, while this number for women was only 16.5% (N=26). Compared to engineering activities, the nature of an internship is closer to that of an engineering job; unfortunately, women reveal even lower involvement in engineering internships.

Table 6-18 suggests that women engineering students in my sample tended to report lower scores (though not statistically significant) in terms of their internship experiences from the perspective of how easy they could find an internship position, t(53.688)=1.523, p=.134, opportunity to do professional works related to their field of study (Seron et al., 2016), t(52.037)=2.773, p=.467, and if this internship experience enhanced their desire to work inside engineering, t(123)=2.773, p=.54. There was no visible gender difference in terms of social relationship with colleagues, t(54.135)=-.017, p=.987. The difficulty women face in securing an internship position foreshadows the challenges they may encounter in finding a job in engineering, as noted by all interview participants. Additionally, the internship experiences of female engineering students, where they are often assigned supporting roles or co-workers perceived to lack experience, can contribute to lower aspirations to pursue a career as an engineer.

University internship experience items	Men Mean (SD)	Women Mean (SD)	P-value	Cohen's d
31. I can easily find an internship in my professional area.	3.54 (1.013)	3.27 (.724)	.134	.277
32. I had/have opportunities to access core and professional engineering tasks, compared with other interns.	3.41 (1.125)	3.27 (.827)	.467	.135
33. I got/get along well with my colleagues.	3.54 (1.072)	3.54 (.761)	.987	-.003
34. My internship enhances my aspiration of working inside engineering after graduation.	3.41 (1.116)	3.27 (.874)	.54	.135

Table 6-18 T-test: University internship experience * Gender

Note: Means and standard deviation were calculated for respondent's answers on a 5-point Likert scale with 1=Strongly Disagree and 5=Strongly Agree.

Taking university experiences as a whole, it seems that women engineering students in my sample reported a higher academic performance and more positive classroom experiences, while men reported more positive after-class engineering activity experiences and internship experiences. We can thus assume that when it comes to more practical activities, women tend to have lagged behind. It is acknowledged that some of these differences are not statistically significant, but they suggest some patterns worth exploring in interviews. Therefore, to dig deeper, I asked women students' feelings about their undergraduate lives during the interviews. To provide better solutions, I asked what support they wanted and if their university had specific support for women engineering students.

6.6 SES comparisons between women

As the semi-structured interviews only involved women respondents, all the analysis concerning SES comparisons in this section only relates to women (N=158). This section considers whether women engineering undergraduates from urban (N=83) or rural (N=75) areas have different experiences, perceptions and career aspirations – it presents an intersectional analysis of gender and SES with respect to women engineering undergraduates in China. Before I begin with the presentation of findings, I provide some rationale for selecting the rural-urban divide as the only measure for SES in this section's quantitative analysis, which is different from the original survey design.

6.6.1 Rationale for the proxy of SES measurement

In Chapter 3 I introduced SES based on Bourdieu's (1987) categorization of capital into economic, cultural, social and symbolic forms of capital. In China, the structure of urban and rural areas leads to an unbalanced distribution of resources, limiting the development of rural areas and undermining the economic capital, cultural capital and social capital held by rural residents (Tang & Xiang, 2015). The urban-rural divide in China is more complicated than merely dualistic. Central government has put great effort into the coordinated development between rural and urban areas, but there remain persistent imbalances that continue to disadvantage rural areas (Chen & Wang, 2024). Since the direct measurement of SES outcomes tend to be unobservable, in the context of my survey analysis, the rural-urban divide is adopted as a proxy for SES.

‘Monthly living expenses’ was initially designed to measure SES as well. It is worth noting that most Chinese undergraduate students live in dormitories provided by universities rather than living with parents, even if their universities are in their home cities (Zhang & Liu, 2007). Thus, monthly living expenses from parents can be regarded as a proxy for economic capital. To further explore the differences in the rural-urban divide, Chi-Square tests were conducted to compare the monthly living expenses of respondents from rural areas with respondents from urban areas. The results indicate that survey respondents from rural and urban areas had significantly different monthly spending, X^2 (6, N = 158) = 43.283, p<.001, indicating that the rural-urban divide and monthly living expenses have repetitive effects. Students from rural areas tend to have lower monthly spending compared with their urban counterparts. This finding is in line with Tang and Xiang’s (2015) observation that the rural-urban divide can reflect the volume of economic capital held by households. Table 6-19 shows that the seven groups of monthly expenses add more complexity to the data and yield similar results to the rural-urban divide. Therefore, I have chosen to remove it as an indicator of SES.

			Less than500 RMB	501-1000RMB	1001-1500RMB	1501-2000RMB	2001-2500RMB	2501-3000RMB	More than 3000RMB	Total
Area	Urban	Count	6	21	118	81	27	5	9	267
		% within Urban /rural	2.2%	7.9%	44.2%	30.3%	10.1%	1.9%	3.4%	100.0%
	Rural	Count	6	45	141	39	6	1	3	241
		% within Urban /rural	2.5%	18.7%	58.5%	16.2%	2.5%	0.4%	1.2%	100.0%
Total		Count	12	66	259	120	33	6	12	508
		% within Urban /rural	2.4%	13.0%	51.0%	23.6%	6.5%	1.2%	2.4%	100.0%

Table 6-19 Crosstabulation: monthly spending among women *rural-urban divide

As for the parental educational background, which was also initially planned to be a proxy of cultural capital, following the similar step of monthly living expenses, the Chi-square tests (Tables 6-20 and 6-21) also show that all survey respondents from rural and urban areas had significantly different parental educational background: father: X^2 (3, N = 158) = 34.142, p<.001; mother: X^2 (3, N = 158) = 25.390, p<.001. There was a lower proportion of rural parents possessing a higher education degree in comparison with urban parents. Again, this finding resonates with the Tang and Xiang's (2015) observation that the rural-urban divide can reflect cultural capital held by households.

		Father with higher education degree	Father without a higher education degree	Don't know	Single parent	Total
Area	urban	49	211	5	2	267
	rural	6	224	6	5	241
Total		55	435	11	7	508

Table 6-20 Crosstabulation: Father's educational background among women *rural-urban divide

		Mother with a higher education degree	Mother without a higher education degree	Don't know	Single parent	Total
Area	urban	28	232	7	0	267
	rural	2	227	8	4	241
Total		30	459	15	4	508

Table 6-21 Crosstabulation: Mother's educational background among women *rural-urban divide

More importantly, I did not anticipate when I designed the survey that there might be a generational issue whereby only a limited number of parents had access to higher education due to the backwardness of education in China at that time (Yue, 2018). Table 6-22 shows that among the 158 women engineering participants, only 21 had a father with a higher education degree and ten had a mother with one. The sample size is thus too small to be engaged with quantitatively. Therefore, for the sake of statistical calculation, parental educational background is also excluded from SES indicators in this section. Nevertheless, the qualitative analysis considers students' cultural capital through their parents' and relatives' educational backgrounds, which were mentioned by interview participants as influential on their choices.

		Father	Mother
Valid	Higher education degree	21	10
	Non-higher education degree	132	142
	Don't know	4	4
	Single parent	1	2
	Total	158	158

Table 6-22: Parental educational background of women students

In short, since monthly living expenses and parental educational background tend to yield similar outcomes as the rural-urban divide, I chose to present only descriptive analysis results pertaining to the urban/rural divide as the proxy for SES in this section, to avoid overcomplicating the SES-related analysis. Science capital is also considered a reflection of SES as a complementary element as it touches upon social and cultural capital. Nevertheless, since the quantitative findings regarding science capital index were illustrated in Section 6.4 and the qualitative data will further explore the manifestation of science capital in Chinese contexts, I have excluded the analysis of science capital from this section.

6.6.2 Career aspirations

Crosstab and Chi-square results (Table 6-23) show a slightly higher percentage (though not statistically significant) of sample urban women students (49.4%) planning a career inside engineering than rural women students (44%), X^2 (3, N = 158) = 2.707, p=.439. Nevertheless, only 21.7% urban women wanted to leave this area after graduation, compared to 30.7% of women from rural backgrounds. This inconsistency arises from a higher proportion of urban women exhibiting unclear and uncertain career aspirations. The rural-urban divide in China can refer to a distinguished gap regarding economic, cultural and social capital in a certain family, so the interview schedule emphasized which aspects of the family SES affected participants' choices and how.

			Inside engineering	Outside engineering	Unclear	Not sure	Total
Area	urban	Count	41	18	7	17	83
		% within Urban/rural	49.4%	21.7%	8.4%	20.5%	100.0%
	rural	Count	33	23	3	16	75
		% within Urban/rural	44.0%	30.7%	4.0%	21.3%	100.0%
Total		Count	74	41	10	33	158
		% within Urban/rural	46.8%	25.9%	6.3%	20.9%	100.0%

Table 6-23 Crosstabulation: Career aspiration among women * Rural-urban divide

Following the pattern in the gender-breakdown section, I also present here how rural and urban women in my sample had different plans to further their study or enter the job market. Table 6-24 shows that a higher percentage of urban engineering women (62.7%) chose to pursue a master's degree than rural engineering women (61.3%), though this difference is not statistically significant, X^2 (3, N = 158) = 2.683, p =.441. A potential explanation could be the financial pressure faced by rural women, compelling them to enter the job market to earn money as quickly as possible. This result regarding graduation choices again will be further reflected by the interview findings in Chapter 9.

			Further study	Work	Not sure	Never think about it	Total
Area	urban	Count	52	14	14	3	83
		% within Urban/rural	62.7%	16.9%	16.9%	3.6%	100.0%
	rural	Count	46	13	9	7	75
		% within Urban/rural	61.3%	17.3%	12.0%	9.3%	100.0%
Total		Count	98	27	23	10	158

% within Urban/rural	62.0%	17.1%	14.6%	6.3%	100.0%

Table 6-24 Crosstabulation: Plan after undergraduate stage among women * Rural-urban divide

6.6.3 Engineering agency

Table 6-25 shows how women respondents from rural-urban backgrounds rate their engineering agency. The independent sample t-test shows that among women engineering respondents, those from urban backgrounds reported higher average scores regarding all engineering agency scales, among which the differences in only two items are statistically significant: N7: 'My parents/relatives/friends see me as an engineering person', t(156)=2.1, p<.05; and N16: 'If I face a setback in the way of pursuing engineering, I take strategic steps to overcome the barrier', t(156)=2.057, p<.05. This suggests that urban backgrounds somehow empower women to be agentic to resist the stereotyped social structures related to women in engineering.

Engineering agency items	Urban Mean (SD)	Rural Mean (SD)	P-value	Cohen's d
1. I believe learning engineering will improve my career prospects	3.71 (.969)	3.64 (.799)	.619	.079
2. I believe engineering can help me see opportunities for positive change	3.69 (.999)	3.51 (.876)	.232	.191
3. I believe learning engineering can make me more critical in general	3.84 (.890)	3.67 (.794)	.192	.209
4. I believe engineering is helpful in my everyday life	3.78 (.951)	3.61 (.837)	.237	.189
5. I believe engineering will provide greater opportunities for future generations	3.72 (.901)	3.55 (.859)	.211	.881
6. I believe a country needs engineering to become developed	4.07 (.921)	3.88 (.929)	.194	.208
7. My parents/ relatives/ friends see me as an engineering person	3.51 (.955)	3.19 (.954)	.037	.335

Engineering agency items	Urban Mean (SD)	Rural Mean (SD)	P-value	Cohen's d
8. I am interested in learning more about engineering	3.55 (1.062)	3.37 (.927)	.258	.181
9. I believe I can understand concepts I have studied in engineering	3.40 (1.023)	3.28 (.924)	.451	.120
10. Others ask me for help in engineering	3.49 (1.005)	3.25 (.917)	.119	.250
11. I can overcome setbacks in engineering	3.42 (1.061)	3.29 (.941)	.424	.128
12. My personal abilities/talents 'fit' the requirements in engineering	3.33 (1.013)	3.20 (.944)	.424	.128
13. I have been strategic in enhancing my engineering capability	3.60 (.936)	3.43 (.932)	.240	.188
14. I have intentionally made choices to focus on an engineering career	3.64 (.932)	3.39 (.971)	.098	.265
15. I have seized opportunities when they are presented to me to enhance my engineering capability	3.76 (.850)	3.51 (.876)	.068	.293
16. If I face a setback in the way of pursuing engineering, I take strategic steps to overcome the barrier	3.86 (.871)	3.56 (.933)	.041	.328

Table 6-25 T-test: Engineering agency among women * Rural-urban divide

Note: Means and SDs were calculated for respondent's answers on a 5-point Likert scale with 1=Strongly Disagree and 5=Strongly Agree.

6.6.4 Engineer image stereotypes

Table 6-26 demonstrates how women respondents from rural and urban backgrounds perceive engineers differently. The independent sample t-test shows that among women engineering respondents, those from urban areas report higher average scores on all scales related to engineer image stereotypes, but these differences are not statistically significant. In other words, women from socially and economically advantaged backgrounds in my sample tend to hold more stereotypical views of what it means to be an engineer. This raises the question of how being stereotyped by the engineer image relates to career aspirations. Again, the qualitative data can provide an explanation.

Engineer image items	Urban Mean (SD)	Rural Mean (SD)	P-value	Cohen's d
17. I believe engineers have to be physically very strong to cope with their work	3.29 (.969)	3.11 (.981)	.242	.187
18. I believe most engineers work with oily machines	2.88 (.929)	2.79 (.905)	.526	.101
19. I believe engineering is not a job for women	2.66 (1.151)	2.41 (1.092)	.165	.222
20. I believe engineering is a dangerous job	2.94 (.967)	2.84 (.885)	.495	.109
21. I believe engineers are unsociable	2.65 (1.087)	2.60 (.959)	.758	.049

Table 6-26 T-test: Engineer image stereotypes among women * rural-urban divide

Note: Means and standard deviation were calculated for respondent's answers on a 5-point Likert scale with 1=Strongly Disagree and 5=Strongly Agree. The higher the score, the more stereotyped it is.

6.6.5 University experiences

In terms of university classroom academic experiences (Table 6-27), women from urban backgrounds in my sample were more likely than their rural counterparts to agree with the statements (though not statistically significant), with the exception of item N22 regarding academic workload: 'There is a reasonable workload of the engineering classes', t(153.869)=-.685, p=.494. Likewise, Table 6-28 demonstrates that women from urban backgrounds rated higher in all statements concerning frequency of attending university after-class engineering activity, among which the significant difference was only found in item N30: Engineering-related undergraduate research experiences, e.g. research seminars, being exchange students as visiting scholar, t(154)=2.93, p<.05.

University classroom experience items	Urban Mean (SD)	Rural Mean (SD)	P-value	Cohen's d
22. There is a reasonable workload of the engineering classes	3.49 (.942)	3.59 (.755)	.494	-.108

23. I have positive and frequent interactions with engineering classmates	3.49 (.977)	3.57 (.832)	.478	.113
24. There is a fair and inclusive climate in engineering classes	3.69 (.854)	3.61 (723)	.437	.025
25. I often undertake important tasks in group work	3.55 (.800)	3.24 (.786)	.007	.396
26. Teachers are interested in me and confident in my professional ability	3.48 (.915)	3.21 (.874)	.062	.300
27. I have enough role models in the same gender, who can inspire me to work inside engineering in the future	3.54 (.991)	3.43 (.873)	.440	.123

Table 6-27 T-test: University classroom experience among women * Rural-urban divide

Note: Means and standard deviation were calculated for respondent's answers on a 5-point Likert scale with 1=Strongly Disagree and 5=Strongly Agree.

University after-class engineering activity experience items	Urban Mean (SD)	Rural Mean (SD)	P-value	Cohen's d
28. Activities held by engineering student clubs, such as Technology-lovers Association, on campus	1.73 (.885)	1.51(.760)	.085	.338
29. Professional activities or competitions held by the department/ university/nation, e.g. Engineering Drawing Competition	1.70 (.822)	1.55 (.827)	.249	.225
30. Engineering-related undergraduate research experiences, e.g. research seminars, being exchange students as visiting scholar	1.63 (.792)	1.34 (671)	.016	.470

Table 6-28 T-test: University after-class engineering activity experience among women * Rural-urban divide

Note: Means and standard deviation were calculated for respondent's answers on a 4-point Likert scale with 1= Not Involved, 2= 1-2 time/year, 3= 3-5 times/year and 4=More than 5 times/year.

A notable pattern relates to internship experience (Table 6-29): women engineering students from urban areas rated a lower score on average from the perspective of how easily they could find internship positions (N38), $t(24)=-.069$, $p=.946$, and had the opportunity to do professional work related to their field of study (N39), $t(24)=-1.137$, $p=.267$. However, it is not statistically significant, and the qualitative findings will further explore the key aspects that enable women to obtain fulfilling internships.

University internship experience items	Urban Mean (SD)	Rural Mean (SD)	P-value	Cohen's d
31. I can easily find an internship in my professional area.	3.26 (.806)	3.29 (.488)	.946	-.031
32. I had/have opportunities to access core and professional engineering tasks, compared with other interns.	3.16 (.834)	3.57 (.787)	.267	-.503
33. I got/get along well with my colleagues.	3.47 (.841)	3.71 (.488)	.486	-.313
34. My internship enhances my aspiration of working inside engineering after graduation.	3.21 (.918)	3.43 (.787)	.583	-.246

Table 6-29 T-test: University internship experience among women * Rural-urban divide

Note: Means and standard deviation were calculated for respondent's answers on a 5-point Likert scale with 1=Strongly Disagree and 5=Strongly Agree.

6.7 Open-ended questions

This section aims to synthesize the open-ended responses gathered from participants in the survey. The short written answers after the option 'other, please specify' in several survey questions were coded and then properly distributed in the above analysis, such as merged with the provided options or through attaching a new value. Therefore, this section only deals with the two independent open-ended questions in my survey, asking participants their reasons for learn engineering at university and the most influential person in their career plans. Descriptive analysis was performed to see how their answers were distributed.

6.7.1 Reasons for studying engineering at university

Participants were allowed a space of 40 characters to briefly describe their reasons for choosing engineering as their programme at university. The answers received were short, usually within 20 words. I coded their answers based on their text and generated themes based on the codes. Non-meaningful answers were deliberately excluded, such as 'oh my god' and 'why should I tell you'. And many of the respondents gave more than one reason, meaning that there could be more than one theme in one response, and/or one theme appeared more than once for a single respondent. Therefore, SPSS may not effectively capture the frequencies at which each single theme manifests. I then turned to Excel to calculate the frequencies at which each theme appeared among the whole sample, men students, women students, rural women students and urban women students.

In total, 28 codes were generated based on these answers, leading to the creation of five themes: educational system (e.g., score limitations and lack of subject-choice knowledge), psychological factors (e.g., interest, self-efficacy and curiosity), important others (e.g., suggestions from parents and relatives), discipline characteristics (e.g., the usefulness of the discipline, job prosperity and high salary), and not a serious decision (e.g., hasty choice). Collectively, these themes account for 494 occurrences. Among the 508 participants in my sample, psychological factors (46%, N=227) were the most common reasons to choose engineering as a subject to study. Discipline characteristics were second (29%, N=144), while educational system (11%, N=53), not a serious decision (8%, N=40) and important others (6%, N=31) were consistently encountered with comparable frequencies, accounting for the least important reasons among respondents.

When examining the responses of women and men students separately, it becomes evident that both genders exhibit a parallel pattern in terms of the frequency and percentage ranking. Nevertheless, Table 6-30 suggests that women respondents reported slightly lower percentages in terms of psychological factors and discipline characteristics (but significance testing was not performed), suggesting that engineering is less attractive to them. The educational system seems to have a larger influence on their choices. Chapter 8 has a more comprehensive illustration in this regard.

			Psycholog-ical factors	Discipline character-istics	Educational system	Not a serious decision	Important others	Total
Gender	Men	Count	161	109	29	25	21	345
		%	47%	32%	8%	7%	6%	100.0%
	Women	Count	66	34	24	15	10	149
		%	44%	23%	16%	10%	7%	100.0%
Total		Count	227	143	53	18	31	494
		%	46%	29%	11%	3.5%	6%	100.0%

Table 6-30 Reasons to study engineering at university * Gender

Regarding the rural-urban distribution among women cohort, Table 6-31 shows that no rural women cited 'important others' as a reason for choosing engineering, reflecting the lack of engineering-related social capital and support among their kin. They were slightly less psychologically attracted to engineering than their urban counterparts (41% vs 47%), while they are more drawn to the high salary and job prospects of this field (31% vs 16%), possibly due to their familial financial constraints (but significance testing was not performed).

			Psycholog-ical factors	Discipline character-istics	Educational system	Not a serious decision	Important others	Total
Gender	Urban	Count	40	14	15	7	10	86
		%	47%	16%	17%	8%	12%	100%
	Rural	Count	26	20	9	8	0	63
		%	41%	32%	14%	13%	0%	100%
Total		Count	66	34	24	15	10	149
		%	44%	23%	16%	10.07%	7%	100%

Table 6-31 Reasons to learn engineering at university among women * rural-urban divide

6.7.2 The most influential people on career plans

In the survey, respondents were asked to write down the most influential person to their career plan. Their answers were brief and easily coded into six groups based on social roles: myself, faculty member, parents, parents' classmates, peers, and relatives. Crosstabulation with Chi-square test was generated in SPSS to see the distribution of the most influential person to their career plans among men and women participants, X^2 (5, N = 394) = 2.883, p=.718 (Table 6-32). The results show that most engineering students tend to seek career advice from faculty members (33.8%) and parents (33%). Fourteen percent of respondents chose themselves as the most influential person on their career plans, indicating that they may be more agentic in making their own decisions. Among this agentic group of respondents, 67% were men (N=37) and only 33% women (N=18). Peers (11.4%) and relatives (7.6%) ranked thereafter. A larger proportion of the sample men students (35.6%) sought career help from faculty members than women (30.1%). This informed the design of interview schedule, directing me to pay attention to women's relationships with faculty members.

			A faculty member	Myself	Parents	Parents' classmate	Peers	Relatives	Total
Gender	Men	Count	93	37	80	1	31	19	261
		% within Gender	35.6%	14.2%	30.7%	0.4%	11.9%	7.3%	100.0%
	Women	Count	40	18	50	0	14	11	133
		% within Gender	30.1%	13.5%	37.6%	0.0%	10.5%	8.3%	100.0%
Total		Count	133	55	130	1	45	30	394
		% within Gender	33.8%	14.0%	33.0%	0.3%	11.4%	7.6%	100.0%

Table 6-32 Crosstabulation: Career consultancy*Gender

When it comes to the rural-urban distribution among women cohort, Table 6-33 shows that parents (37.6%) exerted the greatest influence on plans for their professional trajectory, followed by faculty members (30.1%). A smaller percentage of my sample women students from rural areas (32.8%) sought help from parents than their urban counterparts (41.3%), though not statistically significant, X^2 (4, N=133)=2.556, p=.635. Like the abovementioned result that no rural women respondents sought help from their social circles, this can be explained by the low cultural and social capital possessed by rural parents. Qualitative findings can provide further justifications.

			A faculty member	Myself	Parents	Peers	Relatives	Total
Urban/rural	urban area	Count	19	11	31	7	7	75
		% within Urban/rural	25.3%	14.7%	41.3%	9.3%	9.3%	100.0%
	rural area	Count	21	7	19	7	4	58
		% within Urban/rural	36.2%	12.1%	32.8%	12.1%	6.9%	100.0%
Total		Count	40	18	50	14	11	133
		% within Urban/rural	30.1%	13.5%	37.6%	10.5%	8.3%	100.0%

Table 6-33 Crosstabulation: Career consultancy among women*Gender

6.8 Summary

This chapter examined the diverse social categories of my survey respondents, relating to gender and SES. It investigated how these categories showed distinct or similar descriptive statistical patterns on career aspirations, engineering agency, university classroom experiences, extracurricular engineering activities, internship experiences as well as science and engineering capital.

Unsurprisingly, in my sample, there were statistically significant differences between women and men respondents in terms of their final career aspirations to work inside or outside engineering. This sets the foundation for the rest of this thesis and for the qualitative interviews with a sample of women, to identify the challenges faced by them that might lead to higher attrition and an exploration of how they negotiate and respond to these difficulties. When looking at additional factors related to perceptions and experiences, it is useful to capture from the descriptive analysis that women students, on average, tend to report higher engineering agency, less stereotypical perceptions of engineers, and more positive university experiences, but a weaker desire to pursue an engineering profession than men. This inconsistency raises the need for further explanations of the quantitative findings, suggesting that there might be nuanced aspects not fully captured by numerical data alone.

This chapter also investigated the impacts of the rural-urban divide on women respondents. Though not statistically significant, a slightly higher percentage of urban women planned a career inside engineering than rural women, and women survey participants from urban backgrounds reported higher than average scores regarding engineering agency and university experiences scales. One potential interpretation is that coming from an urban background somehow empowers women to be agentic to resist the social structures surrounding women in engineering. The following interviews explored specific aspects of SES in more detail as well as how their influences are manifested.

When it comes to the results of the adapted science and engineering capital as an aspect of SES, it seems that it works in a slightly different way among Chinese engineering students at universities than in the UK pre-university contexts. No significant gender differences were observed between men and women engineering students in my sample regarding their science and engineering capital scores. Similarly, there are no statistically significant differences in science and engineering capital levels among women with career aspiration within and outside engineering. Some statistically significant differences were found, in line with those reported by Archer and collaborators, in the UK pre-university context (Archer et al., 2015; Moote et al., 2020): engineering students' from urban areas and with a father who has a higher education degree tend to possess a higher level of science and engineering capital; students with higher science capital scores are more interested in pursuing an engineering-related career. The results highlight the importance of adapting Archer's concept of science capital when applying it to the contexts of Chinese engineering higher education. A detailed theorization and adaptation will be presented in the discussion and conclusion chapter (Chapter 10), incorporating insights from both quantitative and qualitative findings.

It is acknowledged that some of the differences presented in this chapter are not statistically significant, but some patterns worth exploring in interviews were identified in the data. The next three chapters present the qualitative findings. They uncover the dynamics and complexities of how gender and SES intersect to exert influences on Chinese female engineering students and how these female individuals respond to social structures.

Chapter 7 Motivations to study engineering at university

As shown by the quantitative findings, gender and SES play a vital role in the experiences and career choices of engineering undergraduates at Chinese universities. Shaped by Confucian patriarchal norms, Chinese women are expected to be submissive, to shoulder more family responsibilities and pursue a perceived to be easier career (Si, 2022; Tan, 2019). While female students in China confront gender norms that tend to disadvantage women in engineering, a difficult and demanding domain, some navigate a complicated and dynamic interplay of factors that guide them towards studying engineering. Findings in this chapter explain how SES and the Chinese educational system serve as social structures driving these female students to learn engineering by exploring their pre-university experiences. These women negotiate a unique set of circumstances and motivations as they consciously or unconsciously break through societal expectations and embark on their engineering education journey. These early experiences and motivations can also have lasting effects on their career choices to continue or leave engineering, together with the influence of university experiences, which are the main focuses of the forthcoming chapters.

This qualitative chapter is not only based on the interview data, but also closely associated with the quantitative data such as the ‘science and engineering capital index’, and the open-ended question in the survey, where participants were allowed a space of 40 characters to shortly describe their reasons for choosing engineering as their programme of study at university. I briefly mention the results of this open-ended question before I move on to the qualitative findings: 28 codes were generated based on their answers and five themes were created: educational system, psychological factors, important others, discipline characteristics, and not a serious decision.

7.1 University admissions system in China

The unique Chinese university admissions system, depicted in Section 1.4, is an important factor shaping female students' motivations to pursue engineering at university. It is under the 'tiaoji' system that many students are assigned to engineering programmes, rather than their preferred choices. More importantly, the score-focused high school education system is designed based on the university admissions system. In other words, it has impacts on both high school experiences and university subject choices.

7.1.1 Prioritizing university before major

As described in Section 1.4, in the Chinese 'Gaokao' system, students are allowed to accept or decline the major allocations assigned by the universities to which they apply. This process is known as 'tiaoji.' The survey results show that there were 40.5% women (compared with 26.3% men) whose first choice was not an engineering-related subject. The narratives from interview participants also indicate that 'tiaoji' drives them into a programme that they are not genuinely interested in:

> I don't have much interest in engineering. It ranks the third also the last in my application list. Because of 'tiaoji', I ended up studying engineering. If I hadn't accepted the adjustment, I wouldn't have been able to pursue higher education at such a good university. If so, the over ten years that I devoted to my education will be a waste. (Jin, Environmental engineering)

As Jin said, it seems that the primary motivation for Chinese pupils to study has long been the aspiration to be admitted to a prestigious university. Many students prioritise the university over the major, often preferring better universities and sometimes choosing less desirable majors. In some cases, it is better than nothing for them. They may not always have a choice if they have failed their preferred choices, leading them to accepting any remaining options. This aligns well with the quantitative findings and can be the reason why so many candidates accept 'tiaoji'. Confined by the educational system and the conventional mindset regarding university admission, their agency to study their favourite subject is sacrificed to secure a position at university.

Five participants expressed concern about their ‘Gaokao’ scores being too low to gain admission to their desired undergraduate programmes at their dream universities, so they just chose to give up their preferred programmes even without giving it a try:

> Starting from junior high school, I had actually wanted to study medicine. However, when I applied for university, my grades were not high enough for top medical schools. And I was not satisfied with those that were less competitive and reputable. I ultimately gave up on medicine programme and chose an engineering programme in a 985-listed university. (Xiao, Computer science and engineering)

7.1.2 Lack of knowledge about undergraduate programmes

On the one hand, from their perspective, at least during high school, securing a better university is deemed more important than pursuing a field of personal interest. On the other hand, students do not really know what they will learn in each programme at university so it is difficult for them to identify their preferred area of study. For example, Xu (Computer science and engineering) said: ‘I just briefly looked at what I would be studying, but it wasn’t the kind of understanding that is very clear’. Components aimed at cultivating students’ interest and introducing university programmes are rarely included in the Chinese high school curriculum.

To some extent, the university admissions policy determines the education system in high schools. School reputation is closely linked to the number of students admitted to prestigious universities, exerting pressure on schools and teachers to improve students’ scores (Dai, Chen & Davey, 2007). Here is a representative example of how participants reflect on their high school education in China upon completing their undergraduate studies:

> Many teachers only emphasized scoring well to get into good university, without providing information about various majors, their future prospects, or the enjoyable aspects of the field. And we did not know much about the admission process as well. (Hee, Vehicle engineering)

According to a survey conducted by IiMedia, a private data analysis platform in China, 39% of respondents believe that the dilemma between choosing universities and programmes poses a challenge for candidates and parents during the application process; 24.2% feel overwhelmed by the complexity of information when filling out the university voluntary application, 17.5% consider the available information insufficient, and 16.9% lack understanding of admission policies (Li & Zhong, 2023). It is evident that, when faced with the first significant life decision, the majority of candidates and their parents find themselves in a state of confusion, necessitating external assistance. However, the existing teaching resources in high schools struggle to address the myriad issues surrounding the university application for each candidate and parent. Yu (Mechanical engineering) said: 'During the university application stage, our teachers all turned off their phones and refused to provide any advice to students. This is because they felt that it would entail significant responsibility as choosing a major can profoundly impact a student's entire life'. Consequently, in the absence of a unified arrangement by schools, teachers tend to choose not to offer personal guidance or recommendations on university subject choices. Due to the limitations of Chinese compulsory schooling, capital embedded within students' families plays a crucial role in shaping their motivations when opting for an engineering programme. Sections 7.3 and 7.4 will elaborate on this issue.

Compared to art and science subjects, engineering is somewhat unique due to its emphasis on practicality in designing and creating systems, structures, technologies, etc. This practical aspect is not extensively covered in the Chinese high school curriculum. This lack of exposure explains why some participants, like Yu (Mechanical engineering), noted that they only became aware of the existence of a subject called 'engineering' after graduating from high school. This indicates the necessity to incorporate engineering elements into the high school curriculum to secure a broader exposure to this discipline before it becomes a consideration for their academic choices.

Finally, many participants did not consider subject choice as a serious decision. Three participants simply made their choices because engineering is the best subject at their dream university. Participants tend to use words such as 'randomly' and 'reckless' to describe their attitude towards programme choice, which is in line with the quantitative findings. In addition to the previously mentioned goal of securing admission to a reputable university, Ren (Computer science and technology) noted that this was because after the 'Gaokao,' she just wanted to liberate herself from the exhausting three-year high school life. Therefore she did not care much about the specific subject she would study at university. To effectively convert students' attitudes, teachers should prioritize emphasizing the significance of subject choice rather than merely highlighting the importance of getting a high score and attending a prestigious university.

This section illustrates how the university admissions system in China directly and indirectly exerts power to influence female students' choices regarding engineering programmes at university. The 'Gaokao' system to some degree contributes to disrupting gendered norms suggesting that girls should not pursue engineering, as it leads to more female students becoming engineering majors. I acknowledge that students must adhere to the systematic regulations in the Chinese education system, but individuals can exercise agency in different ways and may make different choices, such as accepting or rejecting 'tiaoji'. Out of the 24 participants, it is noteworthy that the top preferences of eight students were not engineering-related subjects. All accepted the outcome of being assigned to an engineering programme through 'tiaoji', indicating the robust social construction concerning the significance of attending a desired university on their individual agency. They could choose a less prestigious university with a programme of personal interest, yet they are inclined not to pursue this option. This may serve as the starting point for their struggles during university and in their career choices, which will be illustrated in Chapters 8 and 9.

7.2 Choosing science subjects in high school

In most provinces in China including Shandong, the high school academic curriculum contains three main subjects (Chinese, English and mathematics), three science subjects (physics, chemistry and biology), and three liberal arts subjects (history, politics and geography). Students are required to choose either science or arts subjects in their second year of high school, which is called ‘Curricular Tracking’ (Shim & Paik, 2014; Wu, 2018). Though this policy has recently undergone reforms, as this division is perceived to limit the potential of students (Wang, 2016), and different provinces tend to have different policies, my participants did not keep up with the reforms in Shandong province and all selected science subjects in high school. Engineering programmes at most universities in China only accept candidates learning science subjects, which means that choosing science subjects in high school is the foundation of being enrolled on engineering programmes at university.

7.2.1 The perception of science as superior to arts

There is a trend to choose science subjects in high schools, regardless of gender. This trend has historical roots: China is a country that upholds Confucian thought, emphasizing ethics, morality and literature, but after the Western invasions and the introduction of advanced weaponry, the importance of science and technology became apparent to the Chinese people and educational policy makers (Yang & Deng, 2018).

Schools, teachers, and parents play key roles in shaping students’ choice of science subjects as proxy agents by instilling the perception that science is superior to the arts. Teachers and the prevailing school environment overwhelmingly recommend students to choose science subjects:

> At that time, the school strongly encouraged students, no matter boys or girls, to choose science subjects unless they genuinely struggled with the science curriculum. One reason is that in Shandong province, the threshold for arts subjects at university was particularly high, and they admitted fewer students. (Hou, Geological Engineering)

In Chinese, ‘teachers’ refers to all educators working in educational institutions from early childhood to higher education. In traditional Chinese culture, under the influence of

Confucianism, teachers carry cultural symbolic meaning of authority and power, demanding students respect them and follow their advice (Lo, 2021). As such, they play an important role in Chinese individuals' life journeys at different stages of their education.

Parents tend to hold similar stereotypical views to schools and teachers. Cai's (Geographic information science and engineering) father drew on a popular saying – 'Study mathematics, physics, and chemistry well, and you'll be unafraid no matter where you go' – to persuade her to learn science subjects. Li's (Geography and urban & rural planning) mother regards art subjects as useless, assuming that if a girl chooses to pursue arts, it implies she will be reliant on a man in the future.

This indicates a broader structural context in China that regards science as superior to arts, in the same way as men are assumed to be superior to women. Paradoxically, it serves as an approach to empower some women by distancing them from art subjects. When educational resources are predominantly directed towards science subjects, despite the prevailing norm suggesting that girls are unsuitable for science disciplines, an increasing number of female students manage to opt for science-oriented choices.

7.2.2 Self-efficacy and interest in science subjects

In addition to the impacts of important others, 13 participants held that compared to arts subjects, they are better at and more interested in learning science. They attribute their motivations to study engineering to their self-efficacy and interest in science subjects:

> During junior high school, I felt that conducting chemistry experiments was quite interesting, involving various unusual phenomena […] As for physics, in high school, topics like astrophysics became fascinating. (Yang, Materials science and engineering)
>
> In elementary school, because of good maths grades and quick thinking, I dreamed of becoming a scientist or engineer. During my high school years, I enjoyed delving into mathematical problems […] If I couldn't solve a geometry problem, I could spend an entire afternoon trying to figure it out.

> My maths skills were much above the average. I assumed mechanical engineering requires high maths proficiency, so I just selected this programme. (Mai, Mechanical engineering)

When students possess limited knowledge and information about university programmes, self-efficacy and personal interest in science subjects in high school function as internal driving forces that stimulate their agency in choosing engineering programmes (Cheryan et al., 2017; Ireland et al., 2018; Le & Robbins, 2016). It is worth noting that this psychological state is largely developed under the social influences of important figures in their lives, who provide suggestions or exert unconscious influences on their decisions.

Evidence from participants' narratives suggest that a good teacher in the schooling years can shape an interest in science subjects, expand knowledge, build confidence and even guide life values. Expanding upon the short responses to the open-ended survey question, these narratives offered additional insights into the ways teachers influence the respondents' decisions to pursue engineering. For example:

> The reason I can comprehend engineering knowledge now and have a robust thinking ability is greatly influenced by my high school mathematics and physics teachers. Their teaching methods and style make me feel that science subjects are easier and more interesting. (Kai, Civil engineering)

The role teachers play in these female students' motivations to learn engineering is primarily reflected in their impact on school science subjects, which are often perceived as the foundation of engineering. Students are also more willing to accept professional suggestions and guidance from teachers who usually possess authority in traditional Chinese society. I asked participants about the gender of the teachers they mentioned, and while there were both male and female teachers, the majority were male. It seems that male teachers are regarded by female engineering students as more authoritative and influential in STEM.

Different from teachers, parents not only offer suggestions but also exert unconscious and consistent influence through daily upbringing and the capitals they possess. The next sections elaborate on how family SES affects these female students' perceptions and motivation towards learning engineering at university.

7.3 Engineering capital within the family

As I justified in Chapter 5, the cognitive interviews identified different cultural and language contexts between China and UK, so I translated 'science capital' (Archer et al., 2015) into 'science and engineering capital' in the survey. The independent sample t-test results showed that female and male students share similar means for their 'science and engineering capital' score, with a slightly higher average score for women. This might be interpreted as women needing a higher level of 'science and engineering capital' to overcome the obstacles and constraints brought about by social structures to choose engineering majors. This is supported by participants' narratives that social capital, cultural capital and habitus associated with engineering within their family empowers them to resist the prevailing gender norms.

7.3.1 'Engineering capital' as a manifestation of 'science capital' in engineering fields

'Science' was rarely mentioned by semi-structured interview participants, so I assume that capital associated with science tends to be irrelevant in Chinese and engineering contexts, just as the cognitive interview results showed that the word 'science' is seldom used in daily life in China. Therefore, to better explore engineering aspirations among diverse contexts, it is crucial to see how 'science capital' manifests in the engineering field by adopting the term 'engineering capital'. Moote and colleagues (2020) evidenced that UK students' post-compulsory study aspirations in engineering are strongly associated with 'science capital', which suggests that 'engineering capital' can be established by building upon the notion of 'science capital'.

Archer and colleagues (2015) define ‘science capital’ as science-related forms of habitus, cultural capital and social resources. They quantitatively categorize science capital into three types: the theoretical model of science capital combines scientific forms of cultural capital, science-related behaviours and practices, and science-related forms of social capital. However, in the engineering context and in qualitative studies applying this concept, ‘engineering-related behaviours and practices’ can be a practical manifestation of ‘engineering forms of cultural capital’ and ‘engineering-related forms of social capital’. Meanwhile, obtaining an ‘engineering form of social capital’ usually means that one has an ‘engineering form of cultural capital’ that can be generated by social capital resources. For example, Li’s (non-engineering) father is an architectural engineering designer, and she said: ‘my dad is a big fan of technological stuff and is quite supportive to cultivate my sense of technology, including visits to museums and science and technology centres. When we used to travel during my childhood, my father actually would consciously plan such activities’.

In other words, obtaining social and cultural capital can generate engineering-related behaviours and practices, and these three factors are interrelated in participants’ stories. Therefore, in the attempted qualitative analysis of engineering capital in Chapters 8 and 9, I synthesize the three elements together, along with habitus, to describe the mechanism of how engineering capital affects female students’ motivations to choose an engineering major and career. Among the three aspects, social capital is argued to stand out as the key to influence female students’ aspirations, in which process cultural capital and habitus play a vital role in maintaining the sustainability of engineering aspirations. In this chapter, I first discuss motivations to enter engineering undergraduate programmes. In Chapter 9 I further explore career choices, while in Chapter 10 I provide an overall description of how ‘engineering capital’ functions in the contexts of Chinese higher education.

7.3.2 Engineering-related dispositions cultivated by family-based engineering social capital: interest, self-efficacy and admiration

Family engineering social capital was most frequently mentioned in a straightforward way by participants as impacting their motivations to learn engineering. Developed from Archer's definition, it specifically refers to parents or relatives who study and work in the engineering domain. Engineering-related social capital within the family can serve as an influential figure shaping female students' dispositions toward engineering from an early age, motivating them to pursue engineering at university. Interest, self-efficacy and admiration for engineering as illustrated in this section are regarded as part of 'engineering dispositions/habitus'. Sections 8.1.4 and 10.1.2.3 elaborate further on this term.

Kai's father and grandfather are both civil engineers, working on various construction projects and creating hand-drawn sketches for various projects. Her interest and self-efficacy in engineering has been cultivated unconsciously by her father's working content and consciously by Lego educational toys. She said:

> When I was little, I used to watch my dad draw sketches at home. I found it fascinating, and I enjoyed drawing simple shapes like cubes and rectangles. My father bought me Lego from primary school and I love it. As I entered high school, my interest and performance in other subjects did not compare to those for mathematics and physics. When it came time to choose a major for university, I did not hesitate much and settled on this civil engineering programme that truly captivated me. (Kai, civil engineering)

This early taste in engineering can reflect the cultural capital and habitus instilled in her by her father. There is an old Chinese saying: 'Parents are the first teachers of their children'. While the education system in China focused on exam scores may fall short, parents, through their constant words and actions, can fulfil this role effectively. With the advantage of a family background in the field of engineering, Kai developed her own interests and chose her undergraduate programme based on them. Although Peng did not have any family members working as an engineer, her father often did something related to fixing and assembling, serving as a role model and providing her with opportunities to cultivate an interest:

> When I was little, my dad often fixed things around the house, using tools like screwdrivers and wrenches. If there are issues with sockets or anything else, my dad could fix them. I admired him so much. It was that kind of freshness I found quite fun. (Peng, Mechanical design, manufacture and automation)

Like Peng, neither Jin and Yang had any family members who worked or studied in engineering areas, but their fathers are good at engineering subjects, such as physics and chemistry, cultivating their interest and self-efficacy in engineering from an early age by providing engineering-related cultural capital:

> When I first got exposed to STEM, it was probably influenced by my dad. During that time, he used to buy materials related to maths competitions and bring home small experimental kits for me to work on. I found it very interesting. And I believe just because of these early experiences, I can have nice scores in science subjects. (Jin, environmental engineering)

> My dad is good at chemistry and he won some prizes in chemistry when he was young. He often talked to me about chemistry and I am affected by his passion for chemistry unconsciously I think. So when I knew that I was allocated to material science and engineering programme, I was like, not bad, I can do it well. I can give it a try. (Yang, material science and engineering)

As a subject with strong practicality, engineering is present in various aspects of daily lives. This suggests that adding to Archer's definition, the social form of engineering capital is not necessarily linked to a person having a formal job or degree in engineering; instead, it can involve parents who are interested and capable in engineering practice and can offer opportunities for individuals to become familiar with engineering. This is how social capital can contribute to cultural capital. Hence, the key to fostering engineering aspirations is having opportunities to become acquainted with engineering, discover its charm and cultivate a disposition towards it, especially at a young age.

In addition to interest and self-efficacy, admiration is another key theme regarding engineering dispositions emerging from the narratives of participants. This refers to approval, appreciation and respect for engineering and engineers – such admiration is usually cultivated by parents who are engineers or share similar sentiments towards engineering. Recognition of the value of engineering can serve as an enabler of agency or allow female students to persist in this domain. Yu's story demonstrates how her parents' behaviours and attitudes shaped her mindset:

> My parents are in the business of mechanical components. One day, an elderly professor from the university across the street came to our shop to buy a bearing. Despite being over 80 years old, he shared that he was working on a project related to waste disposal, contributing to our country's environmental efforts. My parents were deeply moved by his dedication, so they gave it to the professor for free. The values they instilled in me from an early age, emphasizing the pragmatism of engineering and the importance of value-creating engineering work. (Yu, mechanical engineering)

There is another circumstance where, being immersed in an atmosphere of engineering from an early age, female students intuitively choose engineering subjects even if they may not have a strong engineering disposition. In this scenario, Yu, Mai and Hee had not shown much interest in engineering:

> My family is involved in the hardware and building materials industry, dealing with the sale of mechanical and industrial components. Given the family business environment, I feel inclined to choose a field related to machinery. It could be considered as a somewhat impulsive decision. (Yu, mechanical engineering)

> The main reason is probably because I feel it aligns with the spirit of my family. Almost all the professions in our family are related to engineering, including construction, mining, and mechanical work. I have been exposed to a lot of mechanical work since childhood, so I have a natural inclination towards choosing an engineering major. (Mai, mechanical engineering)

> My grandfather was an excellent carpenter. Additionally, I have an uncle

> who works as an electrician. As I grew up, I had more interactions with the science and engineering through them. These experiences had influenced my choice of an engineering programme. (Hee, vehicle engineering)

All three chose to leave engineering as a profession. This suggests that a choice without genuine interest or admiration may not be sustainable. Cultivating an engineering disposition might become a crucial bridge between engineering capital and aspirations for an engineering career. Chapter 9 will provide further details regarding career choices and the sustainability of engineering aspirations.

7.3.3 Engineering capital as a remedy for lack of knowledge about university programmes

The role of engineering capital is evident in providing more persuasive, professional and authoritative suggestions and guidance on selecting an engineering programme. Similarly, it works alongside the educational system: when schools fail to give students enough information about university programmes, family social connections carry out this role. From Xiao's perspective, when she felt she lacked relevant knowledge to make a decision, she sought help from her programmer relatives whom she trusted as a proxy:

> As a high school student, I was mostly focused on my studies without actively exploring what each programme and profession entails. But because there are elders in my family who are in the field of computer science, namely my aunt and uncle. Their perspective was that computer science offers relatively better job opportunities compared to other majors, and the average salary is higher. Considering these two factors, they suggested it to me, and I followed their advice. (Xiao, computer science and engineering)

Similarly, Chen's (Computer science and technology) father, working as a technical professional in a company and household appliance repair technician as his secondary job, possesses a strong interest in computers and programming. He constantly encouraged his daughter to learn this subject and deepen her knowledge. Li's (Geography and urban & rural planning) father works in architectural structural design and pushed her to learn a relevant subject at universities. There are too many similar examples to list them all here. It appears that the father as the male parental role tends to be more influential in shaping daughters' engineering choices. Similarly, Archer and colleagues (2012) highlight that fathers play a more important role in fostering sustained science engagement within the family. Additionally, Cian and colleagues (2022) suggest that children often perceive fathers as possessing higher level of STEM expertise than their mothers.

There appears to be a lack of influence from female figures in engineering related capitals and habitus within family and school settings. Engineering social capital, as manifested in participants' narratives, is gendered, which is often overlooked in existing discussions of science capital. Chapter 10 will offer a thorough discussion on gendered engineering capital by drawing on empirical evidence from both pre-university and during university experiences.

7.3.4 The contextual feature of science museums

Finally, I turn to briefly discuss museums, which are popular venues for acquiring knowledge in Western cultures and reflect cultural capital in Western countries but were not frequently mentioned by my participants in China. Among 24 female participants, only nine had visited museums when they were young (before university) and only one acknowledged that visiting museums had any connection to her choice of engineering programme. Visiting museums tends not to make a lasting impression on students. This may be because the overall development level of urban museums in China tends to be relatively low (Zou et al., 2022). The museum industry has not flourished in China as it has in Western countries. Museums are typically regarded as tourist venues for consumption rather than educational spaces, meaning that they have not been widely utilized for the education of pupils, especially in medium- and small-sized cities (Li & Gu, 2022).

To summarize, social forms of engineering capital play a pivotal role in generating female students' motivations to learn engineering. It takes effect through cultivating their interest, self-efficacy and admiration for engineering, generating an environment saturated with engineering, providing authoritative suggestions in subject choice and acting as role models within the field. The engineering form of cultural capital and habitus tends to be reflected in such a way that engineering social capital exerts influence on individuals. During this process, engineering-related habitus is essential to maintaining the sustainability of engineering aspirations. Through analysing participant students' narratives, I conclude that engineering capital possessed within the family shapes students' choice of engineering programmes by acting as a complement to the Chinese compulsory schooling system, empowering female students to challenge traditional gender norms. More importantly, engineering capital is gendered, predominantly demonstrated through male figures. This can be seen as another reflection of the intersectionality of gender and SES in this research.

7.4. Other SES-related implications

As noted in Chapter 3, SES is not simply about material conditions; rather, it embodies a combination of economic capital, social capital, cultural capital and symbolic capital. SES can be a reflective discourse about what and who is valuable and respectable in society. Except for resources associated with engineering, family SES still affects students' subject choices at universities in economic, cultural and social ways.

Engineering subjects were acknowledged by most interview participants for the potential to earn substantial income and achieve relatively easy job placements. This could relate to the 'symbolic knowledge about the transferability of science (engineering) in the labour market', described by Archer and colleagues (2015) as part of the reflection of science cultural capital. As all interview participants are engineering majors, they tend to possess more of this type of knowledge. The quantitative findings in Chapter 6 also substantiate this observation, as these discipline factors were the second most cited by respondents when asked why they chose an engineering programme. The interview findings further confirm that participants from rural areas highlight financial considerations as their key concern when deciding to pursue an engineering education. For example, Rui (Civil engineering) from a rural family said: ‘I just want to earn more money, to give myself a better life and my parents a better life… I need to acquire a technical skill that make me irreplaceable’; while Shi (Mechanical engineering) from an urban family noted: ‘I am lucky that my family can support me to learn any subject I want, so that I don’t need to consider financial returns of what I choose’. This mindset appears again when students make career choices (discussed in the next chapter).

Limited cultural capital within the family tends to be the most frequently cited factor leading to a sense of helplessness among students when facing subject choices after the ‘Gaokao’. Usually, parents who have not received higher education are more likely to lack knowledge on how to guide their children in choosing a university programme. For example, Hou made the decision herself with a casual attitude when applying for university and was allocated to an engineering major because of ‘tiaoji’:

> My parents both have an education level up to junior high school. Due to their limited educational background, they couldn’t offer much assistance with my studies. The decision-making in my academic pursuits was entirely left to me, as they did not have much understanding in this regard. (Hou, geological engineering)

When it comes to those students with well-educated parents, their subject choice tended to be based on their parents’ recommendation. Furthermore, a higher level of cultural capital often corresponds to a broader network of social capital that can be exploited. For example, Ren’s (Computer science and technology) father, a police officer, made this important choice for her after he talked to his friend who saw the positive prospects of computer science and engineering.

In the absence of family support and with high schools often lacking courses that address this, first-generation students tend to find themselves in a state of helplessness. From this standpoint, enhancing high school courses to inform every student about programme choice can be an effective approach to promote social equality.

7.5 Summary

This chapter primarily explained how sample female students chose engineering undergraduate programmes by exploring their schooling and family experiences. In this process, SES has a more pronounced impact than gender, highlighting the intersectionality of these two factors. It typically explains how and why the gender norms become apparently 'invisible' when they make this choice to learn engineering, a stereotypical masculine domain. It touches upon the first research question about science capital, while mainly addressing the second question: How are Chinese female engineering students motivated to learn engineering at university?

School and family are two major fields embedding power relations that are exerted on these female students. It seems that the importance of a reputable university outweighs the allure of a preferred programme for many students. To secure a position in university, a number of female students accept the result of 'tiaoji', meaning that engineering lacks an initial attraction for them. Liberal art subjects are often regarded as being inferior by educational discourses and face more intense competition in the 'Gaokao', prompting a significant number of students, irrespective of gender, to overwhelmingly opt for science subjects. In this case, gender norms towards women in STEM become temporarily invisible or less important. Nevertheless, it is shown that the binary construction of science versus arts mirrors the gender binary in the perceived norm that men are better suited for science, which is socially constructed as superior to arts. In such a context, pursuing science becomes an approach to empower women to 'climb the ladder'. The university admissions system in China is affected by high school education that prioritises exam scores. Consequently, many students find themselves lacking knowledge about university programmes and may struggle to identify their true interests. Within the confines of this educational structure, the scope for individual agency to exert influence may be somewhat constrained, although not entirely absent.

At the same time, the family complement schooling as a field that can provide more or less engineering-related social and cultural capital, facilitating the formation of interest, self-efficacy and admiration for engineering and engineers. Under this circumstance, the influence of gender norms can be partially mitigated through the presence of engineering capital within the family. However, an identified imbalance in terms of who exerts influence over engineering capital on these female engineering students indicates that engineering capital can be gendered and more specifically male-dominated. An initial framework of family-based engineering capital has been set, awaiting further enhancement in the next chapter through the addition of university-based engineering capital. Other family SES-related factors, such as financial status, educational qualifications and social network, are examined at the end of this chapter, linking back to and providing further explanation for the quantitative findings.

When Chinese female students choose an engineering major, the broad educational system and engineering capital they possess tends to override gender norms in shaping their choices. For the participating female engineering students, the dynamic process of making a subject choice is marked by reluctance, compromise, randomness and power relations. This potential struggle at the entry into engineering programmes may foreshadow their struggles throughout university and in navigating later career choices.

Chapter 8 Female engineering undergraduates in Chinese universities

With various biographical histories, habitus and motivations towards engineering programmes, these female students entered a new field, university, starting their journey in engineering higher education. This chapter explores their university life, including social and learning experiences, as well as their gender and engineering subjectivities.

It is intriguing to observe from the descriptive analysis of the survey data that the sample of female engineering students, on average, tend to report higher levels of engineering agency and more positive university experiences, though a weaker desire to pursue an engineering profession than their male counterparts. This chapter provides qualitative illuminations on the nuances in the observed quantitative patterns and uncovers the underlying stories of the female students within the domain of engineering higher education. Overall, the social atmosphere at university is found to be gendered, disadvantaging the experiences and career aspirations of female engineering students as gender heteroglossia.

8.1 Belonging and subjectivities in a male-dominated atmosphere

The survey results show that female students tend to rate their university social experience higher than male students, regarding sense of belonging, classroom climate, group work and teacher-student relationship, though most of these differences are not statistically significant. Among the 24 female interview participants, varied sentiments were expressed regarding their sense of belonging to the engineering undergraduate programmes, as well as their gender and engineering subjectivities.

8.1.1 An apparently strong sense of belonging comes at a cost

In alignment with my quantitative findings – and diverging from most existing findings (see Derricks & Sekaquaptewa, 2021; Tate & Line, 2005; Wilson & VanAntwerp, 2021) – a relatively small number of female interview participants reported lacking a sense of belonging (N=11 out of 24). However, it does not mean that the male-dominated environment does not harm females' social needs – upon closer inspection, I discovered that the apparent sense of belonging claimed by these females turned out to be rather superficial.

The superficiality is evident in participants' explanations for their so-called positive engagement in the group:

> I think, for most female engineering students, they come with a certain mindset, anticipating the potential for loneliness. Being aware of this possibility, they proactively engage in psychological preparation, leading them to perceive the experience as manageable. (Yu, inside engineering)
>
> Some girls choose to only socialize with other girls, and this is quite common. My roommate hasn't even spoken to any male classmates throughout the four years. I feel it's too isolating. So, even in this situation where there are more males than females, I push myself to prove that I can socialize well with all of you. However, forcing myself to be like a boy and socialize with those boys does not bring me happiness. (Hee, outside engineering)

It seems that these female students initially understood the course to be isolating, with internal gender segregation. Under these conditions, they exercised agency to tackle it and create an apparently satisfying social experience for themselves. Yu agentically managed her expectations and was mentally prepared for the 'loneliness' of an engineering programme. Hee took agentic action to perform like a boy to get along with male classmates and performed well in this regard, although she failed to find happiness in this process.

Though they exercised their agency in an attempt to resist gender segregation, whether through psychological preparation or forced socialization, they had to devote more psychological resources to mitigate the perceived 'loneliness' and internal gender segregation resulting from male dominance. It implies that when these female students rated higher (mean=3.57) in the criterion 'I have positive and frequent interactions with engineering classmates' in the survey, this psychological sacrifice remains concealed and the potential impact on their engineering career aspirations cannot be fully captured.

Furthermore, some participants' (N=5) perceptions on 'getting along well with classmates' was derived from the care they received from their male classmates:

> In our class, male and female students get along very well. For instance, when we need to carry particularly heavy measuring instruments for field measurements, it's the male students who take the initiative to handle these tasks. They are also considerate of our feelings. (Peng, inside engineering)
>
> In our class, during the Mid-Autumn Festival, as we transitioned from the first year to the second year, all the male students bought and prepared mooncakes for every female student. It was quite thoughtful. (Chen, outside engineering)

Their sense of belonging is nurtured through the accommodation of male students. They thought they had benefited from the gendered task division and enjoyed the 'gentlemen' culture which is a growing discourse around gender in Chinese society. However, these gender segregations in the engineering domain can reinforce the inferior position of female students. Further illustrations on this point can be found in Section 8.2.

8.1.2 Being marginalized in social life and studies

On the other hand, in the male-dominated environment of engineering programmes, some female students (N=8) explicitly complained about lacking the support of social networks in both their social and academic lives. 'Loneliness' and 'struggling to fit in' were the key terms in their descriptions. Mai (outside engineering) explicitly stated, 'Being in an atmosphere with very few people of the same sex makes me feel very lonely. It's the first time I've felt lonely, never felt it before'. Cai (outside engineering) even mentioned that due to a lack of social interaction, her original personality gradually changed: ‘I used to be a relatively outgoing person, but in the end, I slowly turned into someone with certain social anxiety’. Zheng provided an example showing how female engineering students are socially excluded in the networking and community:

> When I served as the class monitor, I started with confidence, thinking that I would get along well with everyone because I had a personality similar to boys. However, I later realized that there was still a fundamental difference between males and females. For example, they [male students] would create a small WeChat group among themselves, occasionally going out for meals, which, of course, made me, being a girl, feel uncomfortable in such situations, especially when they engaged in activities like smoking and drinking. (Zheng, outside engineering)

From their expressions, we can see that gender essentialism persists, hindering the social interactions between female students as a minority and male students as the majority. Rui (outside engineering) used roommate as an example to illustrate the severe class atmosphere for females: ‘whether it’s for prestigious awards or evaluating a student in need, regardless of how excellent she is, boys refuse to support her just because she is a female’. Six participants raised concerns about unfair voting, stating that the higher number of male participants resulted in them receiving more votes. This was most pronounced during the first year, when they did not know each other well. Hence, it seems that male engineering students are willing to handle heavy tasks for their female classmates but are unwilling to make concessions in voting.

Peer interactions tend to be unregulated in education contexts, but they can dramatically influence whether students feel comfortable in daily social life and are engaged in academic learning (Betts et al., 2011). Read, Burke and Crozier (2020) argue that peer relationships are largely influenced by social positioning and policing such as gender. Mai reflected on how policing strategy reinforces gendered peer relationships in educational contexts:

> During some practical classes, I felt an unexplained discrimination because those male students were unwilling to team up with us […] Some male students deliberately kept their distance from us to appear ‘normal.’ Most of

> them believe that teaming up with us or showing concern might be perceived as femininity or having a crush on us. (Mai, outside engineering)

Five participants used the phrase ‘boys play with boys and girls play with girls’ to describe the segregated socialization situation in traditional Chinese classes. Performing in line with the gendered tradition allows these male students to present themselves as ‘normal,’ facilitating better relationships with their male classmates. Anyone who crosses gender boundaries tends to be judged emotionally and even physically punished (Abrams et al., 2003; Sauntson, 2012). This is how the monoglossic, binary gender discourses marginalize and stigmatize heteroglossia, as noted in Chapter 2. Students thus tend to be segregated to same-sex peers (Carter, 1987; Martin, Fabes & Hanish, 2014); hence, a division exists between female and male engineering students, resulting in female students’ lack of belonging as a minority in the class. William (1989) draws on female marines as an example of women in non-traditional occupations and claims that in the military, men hold most of the power, so they can actively limit women’s involvement in the group. However, in the context of engineering, it seems that male students are less likely to cross gender boundaries, while female students tend to be pushed to cross these boundaries as gender heteroglossia, to fit into the masculine atmosphere. Further discussions is provided in Chapter 10.

Lacking social interactions and networking with their engineering peers can reflect the deficiency of collective agency (Woo, Jang & Henfield, 2015). In addition to social life, this absence of sense of belonging can impact female engineering students’ learning by making the study process isolated, so that they tend to have limited opportunities for communication and learning from others:

> In our class, there were only three female students. I remember when we were forming groups for a project, I asked in our class WeChat group if any group needed an additional member. However, no one responded to me. Eventually, when the deadline approached, the class leader assigned we three female students, to other classmates’ groups. (Die, inside engineering)

Cai (outside engineering) also expressed her concern about finding a group and hoped that teachers would directly assign teams. This awkward situation has the potential to diminish their enthusiasm for engineering learning, which may ultimately drive them to choose a career outside engineering to avoid such social embarrassment.

Except for difficulties in collaborative study, social isolation is a problem when they encounter problems in their study. Five participants tended to spend time solving problems on their own, despite the usually ineffective outcomes:

> When facing challenges, my first reaction is to introspect and isolate myself. I mainly search for information online, spending afternoons in chilly classrooms with my laptop. Sometimes, despite spending the entire afternoon, I find nothing. It's a pitiful sight. As the deadline approaches, anxiety builds up, leading to self-doubt. (Ren, outside engineering)

In addition to marginalized interactions with male classmates, frequent discouragement from faculty staff also makes them feel increasingly estranged from the field. Even though they have chosen engineering, university teachers, whether consciously or unconsciously, convey the idea that engineering is not suitable for females, subtly influencing their decisions regarding postgraduate studies and employment:

> University teachers discourage us from studying mechanical engineering. Every one of them says the same thing. Sometimes, during lectures, they talked about the current employment situation that the employers are often reluctant to hire them [females] because many hands-on mechanical activities are often not participated in by female students. Hence, their suggestion for female students is to study subjects of arts and humanities, and find an easy and stable job. (Mai, outside engineering)

There is a hidden curriculum across educational institutions in China, whereby teachers play a role in reproducing gendered norms and affecting the choices of students (Wang, 2020; Yu & Winter, 2011). In a Confucian culture that emphasizes seniority and teachers' authority, elders and teachers tend to have an essential influence on participants' attitudes and responses to gender norms. As Chen (outside engineering) explained, 'I was chatting with a faculty member I really admire, and he suggested that it would be better for girls to seek a more stable job rather than being an engineer in the future. I think what he said could be a nice option'. Students tend to take their university teachers' suggestions quite seriously. Faculty members thus can become an important proxy agent with authority when undergraduate students exercise their reflexive mode of agency.

The faculty members discouraging female students mentioned by participants were largely male, highlighting issues around the institutionalised culture of gender, disadvantaging females in pursuing engineering careers. Zheng (outside engineering) had a similar experience when her male university teacher suggested she not take an engineering internship position because it would be so tiring, saying that the working environment is terrible and unsuitable for a girl. The influences from important others at university on female engineering students tend to be gendered. Hence, it is necessary to build a faculty team of gender-sensitive lecturers who are aware of gender dynamics in their teaching practices and create an inclusive learning environment.

Meanwhile, it seems that female lecturers and supervisors are more likely to assist female students by providing them with more opportunities and spiritual support. Jin (inside engineering) claimed that female faculty members can better understand the situation of female students because they have experienced what these students are going through. It is often difficult for a male, who benefits from gender privilege, to fully comprehend the challenges and dilemmas faced by a female living in a patriarchal society (Kimmel, 2018). With more faculty members of the same gender, female students could build allies with them and thus find it easier to fit into the engineering environment (Balakrishnan & Low, 2016).

Yang (inside engineering) recognized the importance of female leaders in the faculty by expressing that: 'I think perhaps what makes our department a bit different is that our dean is a woman and the head of our department is also a woman. So, it's possible that this might be a reason why our school does not discriminate much between male and female students'. She also explained her wish for more female faculty from the perspective of collective agency by claiming that more younger generations of female would be encouraged to pursue engineering if more females entered this domain and made significant contributions as appropriate role models (Beaman et al., 2012).

In summary, female students, as gender heteroglossia, tend to have more or less difficulties in adapting to the male-dominated engineering programmes, regardless of family SES or personality. This challenge is largely attributed to entrenched gender essentialism in Chinese society, negatively impacting the learning and career choices of female engineering students. The institutional culture in engineering needs to become more inclusive by disrupting the entrenched gender essentialism and biological determinism. It is also noted that a lack of sense of belonging in engineering programmes can be regarded as a result of insufficient university-based engineering social capital. Section 9.4 and Chapter 10 will provide further elaboration on this term.

8.1.3 Three types of gender subjectivities

As noted in Chapter 2, the term 'subjectivity' rather than 'identity' is adopted to emphasize the sociology-centred nature of this research. During the interviews, participants were asked to identify their social gender and give reasons. It is worth noting that in the Chinese language, the term 'social gender' has been advocated to challenge essentialist views of gender by adding social connotations (Wang, 1997). I received three types of responses regarding identified gender: masculinity, femininity, and gender-neutral. Masculinity here refers to female masculinity as my participants are all females in terms of biological sex. The term 'gender-neutral' is directly extracted from interview participants' accounts and refers to the ability to perform masculinity or femininity or both according to the demands of a given situation.

Six participants identified themselves with femininity, aligning with their biological sex. What they told me revealed a commonality: they were brought up in a typical girls' way, indicating the strong impact and discipline imposed by their family members as proxy agents. Some who identified as feminine did not seem to have considered their gender subjectivity before. Responses included: ‘I have never thought about this, but I guess I am a woman because I was born as a girl and brought up as a girl’ (Xiao, inside engineering); ‘I don’t think social gender is anything different from my biological sex’ (Fu, outside engineering). In the Chinese language system, there is no distinction between gender and sex, as the word ‘Xingbie’ (literally meaning ‘different natures’) is used to separate women/female and men/male (Hershatter & Zheng, 2008). It indicates a strong gender essentialism in the discursive form perpetuated in Chinese culture.

Some participants (N=10) acknowledged the presence and even prevalence of (female) masculinity within themselves. Their articulations demonstrated a separation of gender from their biologically sexed bodies, recognizing the existence of masculinity in females and femininity in males (Connell, 2005; Francis, 2012). It has the potential to disrupt the heterosexual matrix (Butler, 1990, 1993) by taking on interrupted roles traditionally assigned to specific binarized gender groups. There were several examples provided: ‘I am not as gentle and emotional as girls’, ‘Girls are weaker, but I am not’, ‘I am boyish and I often forget that I’m a female’, and ‘I am naughty and always climb up and down like a boy’. Although my participants tended to demonstrate gender dualism when indicating women and men as separated social groups (see Section 8.1.4), gender crossing was observed when they talked about their own gender subjectivities by thinking that they were like boys and possessed masculine characteristics. Kai even expressed her wish to become a male:

> I often joke with others that if I were given the choice, I think I’d prefer to be a guy. I just feel that being a girl can be quite troublesome. You have to pay attention to many things, like your appearance. Sometimes your abilities are questioned. I always feel that if I were a guy, especially in the field I’m studying, it would come with much fewer obstacles. (Kai, inside engineering)

As exemplified by gender heteroglossia (female masculinity), women who enter the field of engineering may find themselves better suited to the engineering environment compared to those displaying gender monoglossia traits (female femininity). Kai's interpretation of 'gender heteroglossia' appears to challenge Sauntson's argument (2012) that individuals who defy gender boundaries tend to face emotional and even physical repercussions. It seems that this outcome depends on context. In the context of engineering, survival may favour female masculinity over female femininity. This may connect to how they perceive they fit in the male-dominated environment in engineering programmes and workplaces.

The participants who identified themselves as gender-neutral (N=8) are inclined to present roughly equal levels of feminine and masculine traits and perform and adapt their gender as circumstances dictate. They are often able to assume roles and responsibilities traditionally associated with both males and females, indicating a potential disruption to the dominant gender order. Meanwhile, some participants perceived their gender as something that could be switched as needed, which reflects the operation of gender performativity. Here several examples illustrate the above three features:

> I feel like I have no gender and can switch as needed. (Xiang, inside engineering)

> I am the class committee secretary, and I believe that the responsibilities I shoulder within this class are often greater than those of many, regardless of whether they are male or female. Therefore, I feel that I am taking on both male and female roles, and as such, I consider myself gender-neutral. (Rui, outside engineering)

> During my work, I sometimes find myself exhibiting characteristics traditionally associated with femininity, such as being diligent. However, my personality sometimes tends to be more tough and laid-back, similar to traits often associated with masculinity. Therefore, I am unsure of how to define my social gender, and perhaps I could be considered gender-neutral. (Zheng, outside engineering)

This gender-neutral state can be shaped by the social surroundings with which individuals constantly interact. This can be seen in Hee's reflexive examination of her inner conversation: she found that by avoiding characterizing herself as a woman, she feels stronger and better able to cope with the gendered social norms in engineering:

> Because there is often discrimination against women in society and the workplace, especially in the engineering field. When you define yourself as a woman who is not treated equally by others, you tend to give yourself certain hints which can make you feel less confident and ambitious when doing things. So I think I can be a woman in daily life, but a man at work. (Hee, outside engineering)

Overall, the female engineering participants in this study exhibited a relatively lower degree of self-identification with their social gender as female, while the majority aligned themselves more closely with either a masculine gender subjectivity or a gender-neutral one. This finding among female engineering undergraduates aligns with research on female engineers, suggesting that they tend to make their femininity more invisible to appear more credible in their careers (Saavedra et al., 2014). The varying gender subjectivities mainly derived from how they were brought up and how they perceived their surroundings in engineering undergraduate programmes. This highlights that gender subjectivities, being complex and multifaceted, can be shaped by the interaction of social structures and agency. More importantly, similar social structures can lead to different gender subjectivities because of the diversity of their family backgrounds, university encounters, the information they are exposed to and personal agentic approaches to social structures.

8.1.4 Perceived engineering subjectivities and images of engineers

Quantitative results show that female engineering students in the sample tended to rate higher in terms of most engineering agency items, except for engineering subjectivities, interest and self-efficacy. Mixed engineering subjectivities were found in the qualitative data (interest and self-efficacy are further illustrated in the next two sections). On the one hand, most interview participants mentioned feeling mismatched with engineering, complaining about how difficult it is for them. A small number of participants, however, demonstrated a high level of recognition of their engineering subjectivities, such as: ‘myself as an engineering person', 'engineering approaches to handling matters', and 'engineering way of thinking'. On the other hand, when participants described their engineering subjectivities, a sense of pride emerged, which in turn enhances their engineering subjectivities. In other words, whether they opt for a career inside or outside engineering, they are proud of being an engineering student with a scientific and technological logic, compared with students learning humanities and social science subjects:

> I believe engineering is closely connected to the origins of things. Whenever I delve into the source of a particular issue or item, I always find engineering. I prefer to reason things out, emphasizing logic rather than solely discussing emotions. I am not saying humanities are not good, but with engineering, I can have the capacity to address not only fundamental problems but also more challenging ones. (Yang, inside engineering)

Based on a traditional perception of engineering, these female students tend to identify themselves as engineering individuals due to their acquired engineering way of thinking and doing, which they believe to be superior. They also see themselves as 'superior' to other women who learn arts and humanities, and in most cases position themselves as being 'masculine' or 'gender-neutral'. In this way, they are reproducing this binary construction of sciences versus arts and humanities, which is linked to the binary construction of men and women.

But while they possess pride over other women, they still perceive they are less capable than male classmates in terms of the engineering way of thinking. For example, Ren said: 'I think there are innate differences between boys and girls. I do not emphasize it as a matter of strength or weakness, but rather as different areas of expertise. Boys may excel more in areas such as structural and spatial imagination'. Thus, when it comes to career decisions, this sense of pride seems to be insignificant. Their apparently robust engineering subjectivities tend to exist in comparison to fields like art and humanities, but they lack the sustaining factors of strong interests and self-efficacy, indicating a diminished agency to persist in the field of male-dominated engineering.

Summarizing insights from participant narratives, the perceived attributes associated with engineering and engineers include innovation, interest, a practice-oriented nature and a commitment to craftsmanship. At the same time, certain negative aspects such as a lack of social communication, the tedious and demanding nature of the profession, and a potentially harsh working environment emerge. Despite the perceived hardships, there is a recognition of prosperous job prospects, the potential for substantial contributions to national development, and the allure of high pay. Encompassing gender norms, it seems that all the above-mentioned attributes are conventionally associated with males.

A total of 19 interview participants held that women and men are different in their characteristics, thus they are better suited for different roles and positions. Based on the interview transcriptions, women tend to be described as more patient, responsible, meticulous, diligent, skilled in communication, emotional, obedient, considering and timid, thus they are more suitable for art subjects and administrative work. Extracting their descriptions of men's features, I find that the majority emphasize men's advantages in the field of engineering, such as being more confident and interested in engineering, better spatial imagination, excelling in STEM thinking, divergent thinking, and logical thinking, brave, easier to persist in engineering, proficient in hands-on tasks and skilled in technological processes. Women's capability in engineering is more likely to be doubted without a factual basis. It can be seen that gender essentialism and biological determinism persists severely among my participants.

In Chapter 6, I posed a question based on the quantitative results: why do female engineering students exhibit less stereotypical perceptions of engineers yet still encounter a higher attrition rate in the field? In line with the quantitative findings, most of the interview participants did not perceive engineers as unsociable males with strong physical strength working with oily machines. Nevertheless, through their narratives, a notable contradiction emerges in their perspectives on women in engineering. On the one hand, they subconsciously view themselves as being at a disadvantage in the engineering domain; on the other hand, they embrace a modern feminist mindset, believing that women can undertake tasks equivalent to those of men. For example, Cai (outside engineering) expressed low interest and low self-efficacy in engineering, claiming that she will not pursue it as a career. However, when asked: ‘Do you agree that women are not suitable for engineering?’, she responded, ‘women can do anything. I feel that there is no field unsuitable for women. In any domain, there are certainly outstanding female achievers. There are actually many females excelling in engineering, and this field should be evaluated based on ability rather than gender’. Xu (outside engineering) also believed in women’s capability to handle any difficulties, but she emphasized that her decision not to pursue engineering professional jobs was based on her own reasoning (such as seeking a stable job), which did not necessarily represent all women. It is noteworthy that these individuals harbour beliefs that their personal experiences may not necessarily represent the broader female engineering student population.

Consequently, considering the implications of modern feminism and traditional gender essentialism, female students are inclined to assign lower scores in agreement with the stereotyped items presented in the survey which describe the general population, but this number is not directly linked with their own career choices. This again evidences the limitations of using merely quantitative methods to understand sociological issues.

8.2 Gendered practical tasks

Numerous engineering disciplines require students to perform physically demanding tasks, such as carrying heavy instruments, conducting dangerous experiments, working in adverse weather conditions and even climbing steep cliffs. In the above scenario, as stated by participants, university instructors often assign such tasks to male students (Riney & Froeschle, 2011). However, the purpose of the patriarchy granting women privileges is not to show favour to women, but to reinforce men’s dominant function in gender relations by solidifying the objectified characteristics of women being loved, cared for, and disciplined. As Cai (outside engineering) stated, ‘I really dislike the term “pampering your girlfriend into a little princess” popular in current online discussions. The word “pampering” implies that males have a superior position, which I find very uncomfortable’. In their recent research Cunningham, Hill and Zhang (2022: 66) attempt to theorise ‘gender equality with Chinese characteristics’, stressing a gender binary with specific expectations for females and males, though with the best intention to promote women’s rights. Furthermore, there is a group of self-described feminists in the online space who indulge in the privileges brought by their femininity while neglecting their obligations (Han, 2018). When women accept the privileges provided by men, they are likely conforming to the patriarchal essentialist gender rules – this includes Zheng, who took boys’ help for granted and assumed that without it, girls would be unable to handle physically demanding tasks.

> It’s tiring and dirty, just let him do it […] Boys should take care of girls [during fieldwork]. If boys don’t do that, girls might face challenges in certain aspects. For example, when it comes to sampling or hiking, if there are no boys to help, girls would have to carry the stones and climb the mountain by themselves. How would that be possible? (Zheng, outside engineering)

The gendered assignment of practical tasks can exaggerate gender segregation in engineering, thus enhancing gendered habitus. It has been shown that teachers’ practices in the classroom can either exaggerate or minimize gender segregation (Martin, Fabes & Hanish, 2014). Some interview participants were aware that the ‘favouritism’ shown by teachers towards female students was a veiled deprivation of practical opportunities for them. Yu claimed that this can worsen female students’ isolation:

> Their initial intention is not bad; they want to help female students out of humanitarian care. However, this leads to female students being excluded from some projects, creating a sense of alienation. In later team projects, male students might prefer teaming up with other male students, finding it more convenient and casual, without having to consider female students. (Yu, inside engineering)

Mai mentioned how female students lose the opportunity to make concrete improvements in learning:

> During practical sessions, most faculty directly prevent female students from getting hands-on experience and instead ask male students to help. They end up completing the entire course on behalf of the female students, then girls have little improvement. While some female students see this as enjoying preferential treatment, I think equality between male and female students is essential. Female students should handle them independently, without having male students do it for them. (Mai, outside engineering)

Mai seemed to harbour a fairly egalitarian mindset towards males and females, but in practice, she still accepted the teachers' assignment. Many female participants were aware of the nature of this unfairness. However, they tended to passively accept this 'favouritism' and did not actively seek to break the cycle of unfairness. This was partly because some female students themselves have accumulated gendered habitus (Bourdieu, 2001) and have reservations about dirty and laborious tasks, as discussed by participants Jin and Rui:

> There are indeed many female students who dislike participating in these experiments because they are not clean. Because the experiments we conduct, such as dealing with sewage and mud, are very dirty and smelly. (Jin, inside engineering)

> On the construction site, every day, it involves twisting steel wires under the sun while witnessing the mixing of concrete for pouring into the grey barrels. The extremely harsh working conditions can be the reason why female students like me are not willing to choose such a path. It will also be unsafe to send a girl to work in a remote construction site. (Rui, outside engineering)

This gendered habitus could be the consequence of the entrenched gender norms ingrained in their upbringing, where girls are expected to be soft, clean and pure, while boys are assigned roles involving physically demanding labour in adverse conditions and care for girls. While some female students understood the potential consequences of lacking practical experience and aspired to acquire excellent professional skills, they were largely constrained by the social norms associated with traditional gender roles. In a state of ambivalence, they find themselves powerless to change the situation. This could explain the quantitative finding of a slightly lower means from female students' answers than male students in relation to the frequency of engineering professional activity involvement. On-campus engineering professional events are more practice-oriented, sharing more similarity with being an engineer.

It is worth noting that being born in rural areas might lead to some girls having the experience of dealing with so-called 'dirty' work. For instance, Peng mentioned that an unfavourable working environment 'is no big deal for me. I am used to the dirty environment as I often played in mud and rolled around in the corn fields when I was little'. However, no other female participants from rural families expressed similar sentiments. Further research is recommended to explore whether a disadvantaged SES background can alleviate gender norms in this regard.

Females' safety in a remote venue, as raised by Rai, is another concern. This is intricately associated with females' perceived physical weakness and vulnerability in sexual contexts compared with males. The apparently unchangeable disadvantages associated with being female can be mitigated through ideological and practical interventions within society, such as nutritional enhancements and physical empowerment for females, and the cultivation of a higher legal consciousness among citizens.

Although different from numerous existing research claiming that female engineering students often lack the opportunity to lead group work and undertake less important tasks (Tonso, 2007), most participants in this study (N=18) said they had equal chances. This also resonates with the quantitative pattern in my research that female respondents tended to rate their university group work experience higher than male students on the item 'I often undertake important tasks in group work'. Nevertheless, an observation reveals that females tend to assume indoor roles in group fieldwork tasks. This scenario illustrates another instance where females are denied the opportunities to accumulate practical experiences:

> In fieldworks, males generally handle physically demanding activities such as running routes and collecting data outdoors. In contrast, female students assist in tasks that are less physically strenuous, such as paperwork, upon

> the return of the male students. (Zheng, outside engineering)

In addition, participating in engineering skill competitions is also a great opportunity to enhance practical skills. A few interviewed females observed that engaging in engineering skills competitions provided them with an interest in engineering:

> Competitions helped me gain a better understanding of the practical aspects of my field. I got to explore the workflow of my profession, which was more interesting than learning theoretical knowledge in the classroom. (Yi, inside engineering）

However, it is worth noting that only a few female participants had experience of attending competitions, aligning with the quantitative findings. As female students are less likely to engage in hands-on activities in their daily academic life than their male counterparts, they thus lack confidence or eagerness to take part in related competitions. Consequently, they may miss out on valuable opportunities to cultivate an interest in engineering. This highlights the need for universities to consciously provide more opportunities and encouragement to female students to participate in hands-on practices, including competitions.

Many participants highlighted that during these hands-on activities they discovered an interest and passion for engineering. Seeing theoretical knowledge transform into tangible outcomes in reality helped them understand the charm of engineering:

> Upon engaging in experiments, I found it very interesting. In fact, engaging in scientific research is sometimes akin to opening a blind box. Until you conduct tests and experiments, you will never know the true nature of the sample. There may be many influencing factors at play, turning the process into a continuous quest for discoveries. (Yang, inside engineering)

> The university implemented a policy requiring students to contact tutors and engage in experiments from the second semester of the second year. As I gradually got involved, I found that it was not as tedious as what was portrayed in textbooks. There is a lot of enjoyment in conducting experiments to see various results. In the first two years, I did not plan to pursue further studies, but as I delved deeper in experiments, I eventually decided to pursue further studies in this field. (Jin, inside engineering)

From the accounts above, it appears that opportunities to engage in engineering experiments can promote the fostering of genuine interest, which can be a key factor leading to sustainable engineering career aspirations. I would emphasize the importance of experiments and practical experiences in challenging the stereotype that engineering is not a 'girls' thing'. When female students are allowed equal chances in hands-on activities, interest and competency might be cultivated and enhanced. However, apart from limited hands-on opportunities during their undergraduate studies, girls tend to have fewer opportunities to engage with engineering related scenarios or games from a younger age compared with boys (Brown & Tam, 2019). If these female students had not been accidentally enrolled in an engineering programme, they might never have had a chance to be so close to engineering experiments or to embark on their career journey in engineering. It would be advisable for universities and schools in China to collaborate, providing pupils, regardless of gender, with more opportunities to experience the allure of engineering experiments and activities even before they make their subject choices at university.

8.3 Gendered assessment

It appears that institutional approaches to assessments are gendered and problematic for female engineering undergraduates. According to the narratives of my participants, they not only face limited chances for practical experiences, but also 'enjoy' lower standards and requirements from instructors in terms of hands-on tasks (Kombo, 2004):

> In a task of disassembling an engine, male students needed to complete it within one hour, while the requirement for us girls was like to finish it within two hours. At this point, regardless of whether I am capable, I have received special attention. In fact, it's also a form of inequality towards the male students, isn't it? We can't always say that inequality is always detrimental to us, but in some aspects, we have indeed suffered some harm as our ability can't be truly improved. And we would doubt our real capability, especially compared with our male classmates (Hee, outside engineering)

Hee acknowledges the unfairness towards males, while also recognizing the potential harm it can generate for females. Lower assessment standards for female engineering students can hinder their improvement in engineering competency and skills, especially those skills required in the engineering workplace. Meanwhile, as they know they can achieve the same scores as male students but are allowed more time to complete a task, their self-efficacy is not enhanced.

Most interview participants (N=22) observed that female students on the whole attain higher grades than male students in exams at university. Zheng (outside engineering) provided specific details for her class: 'In our class, out of eight female students, seven have received scholarships, and they are ranked among the top seven in terms of academic performance'. However, it seems that female students do not exhibit corresponding levels of high self-efficacy, which aligns with the quantitative findings presented in Chapter 6. Different assessment standards for hands-on activities between females and males may be one of the reasons for higher grades among female engineering students, but its impact can be quite limited. This is because in China's exam assessment system at university, scores on written exam papers account for the majority of a student's final grade.

Xu ascribed her lack of self-efficacy to the inherent difference between males and females, endorsing gender essentialism and biological determinism. Even with higher scores, she believed that her male classmates were more capable in engineering:

> Male students excel in coding skills; even if their grades may not be outstanding, their coding abilities are remarkable. The assessment of proficiency in the field of computer engineering and technology should not solely rely on grades. We might excel in theoretical knowledge from textbooks, but our ability may be limited to that. Their expertise is versatile, even though it may not necessarily be reflected in higher exam scores; however, they demonstrate practical proficiency. (Xu, outside engineering)

We can see from the participants' narratives that under the powerful constraints of gender norms, achieving high scores seems not to effectively enhance female students' engineering self-efficacy; rather, it may lead them to believe that their academic achievements are a result of rigid memorization of textbook knowledge. Six participants mentioned that they primarily rely on memorization to deal with exams rather than a thorough comprehension of engineering knowledge. For example, Zheng (outside of engineering) highlighted that: ‘I rely on memorization every time for exams, while boys might rely on understanding. There are a lot of things that require understanding, but I struggle with those things’. These female students tend to subject themselves to social constructions that girls are good at memorising, but boys are better at rational thinking. Participants tend to be less confident in their real competency in engineering practice, indicating that current assessments pay too much attention to written knowledge and fail to reflect the skills needed for the workforce in engineering.

In addition to their hard work in memorizing textbook contents, three participants mentioned their intention to prove that females could also do well in engineering as a reason for striving for higher grades. This resonates with Ignacio and colleagues’ (2021) argument that the higher academic performance of female engineering students is due to their higher motivation to overcome the adverse gender norms on females learning engineering.

Ironically, the high grades achieved under the current assessment system does not lead to a sense of achievement and self-efficacy, but feelings of frustration and powerlessness. This sense of defeat can result in a vicious cycle where low self-efficacy leads to hesitation and reluctance in taking action, affecting both social and academic aspects of university life. For example, Cai is a case in point:

> One time when we had an assignment, I read a lot of literature, found many new methods, and successfully completed the assignment. However, I later found that my core method was just a starting point, and there was more in-depth research by a male student. I felt very frustrated, and my personal confidence was undermined [...] I had a sense of inferiority compared with boys, wondering if others would think I’m not capable or would not want to team up with me. I think it’s a kind of self-suggestion that gradually weakened my sense of belonging. (Cai, outside engineering)

From Cai’s narrative, it is evident that a sense of belonging and self-efficacy in engineering are interconnected. Low self-efficacy related to being female in engineering can undermine a female student’s agency to actively engage in group activities, thus weakening her sense of belonging. These negative psychological experiences are derived from the interplay of agency and social structures, with the potential to lead to the attrition of females from the domain of engineering after graduation (Bell et al., 2003; Yang et al., 2017).

Sample female students typically work hard to study textbooks and achieve good grades, yet it does not necessarily mean that they find studying engineering easy. On the contrary, they (N=21) generally perceive the engineering professional courses as difficult, with some even entertaining thoughts of ‘considering dropping out and re-taking the Gaokao’ (Ren, outside of engineering), noting that ‘I was scared at the mention of programming’ (Fu, outside of engineering). We can imagine the diligent efforts exerted by these female engineering students, despite incurring substantial psychological costs, to maintain a commendable academic performance. However, throughout this process, there is a discernible decline in their self-efficacy, and concurrently, their passion for engineering also diminishes:

> Initially, I approached my studies with great confidence, but as I delved into coding, I did not find it as fascinating as expected. Throughout the learning process, I faced numerous setbacks, and gradually, my enthusiasm waned. I no longer had a strong passion for and dedication to exploring this field. (Chen, outside engineering)

Hai (outside engineering) bluntly stated that it was too difficult when asked why she did not consider becoming an engineer. Beneath the surface of apparently glamorous high grades, the Chinese engineering female students conceal scarred hearts from numerous days and nights of ambivalence. They have exerted huge efforts and tacked various challenges, yet what they have gained is not a true acknowledgment of their abilities but rather the persistent belief of internalized doubt that ‘I am not capable of engineering’.

To summarize, according to participants’ narratives, two approaches regarding gendered assessments were identified: 1) different assessment standards for female and male students in hands-on activities; and 2) assessments may not reflect the practical skills needed for working in engineering, which further enhances the stereotype that women are good at memorizing. The self-efficacy of female engineering students could be sacrificed under this institutional assessment system. It is thus suggested to assess both the academic and practical performance of female and male engineering students equally.

8.4 Participant suggestions for engineering undergraduate programmes

It is noteworthy that all the participants asserted that there was no specific support for female engineering students in their studies and employment at universities. The only initiatives mentioned were ‘girls’ day’ and ‘women’s day’, during which female students receive gifts from male students. Importantly, these initiatives are not specific to engineering students but are inclusive of female students in all programmes. This does not make any difference to supporting female students in terms of engineering engagement.

After elaborating upon both the positive and negative university experiences of female engineering students, this section summarizes, in my own words, the suggestions provided by interview participants for enhancing engineering undergraduate programmes to support female students. These suggestions were provided based on the university-based engineering capital (see Section 10.1.2.1).

A first suggestion was providing psychological counselling services to address their mental health needs and increase opportunities for female students to engage in hands-on activities and practical experiences. Second, inviting more female engineers or researchers to deliver speeches, as role models, to offer valuable insights and inspiration based on their successful experiences would also be helpful. Third, the recruitment process can be improved by restricting companies that exclusively recruit males from entering the campus for recruitment and establishing a recruitment platform specifically targeting females. Further, it would be advisable to organize activities promoting gender equality in the engineering field and to leverage supportive alumni to ensure equal job opportunities for female engineering students. Lastly, initiating employment-related speeches from the first year of university enables students to formulate strategic plans for their academic journey and future careers at an early stage.

I note these measures here because I believe that female engineering students are in the best position to understand how their needs can be genuinely addressed. The subsequent discussion chapter will further consolidate these suggestions and draw implications based on the comprehensive analysis and findings of the study.

8.5 Summary

This chapter explored the perspectives held by female engineering students regarding their sense of belonging, the learning and assessment process, gender and engineering subjectivities under the prevailing social structures of gender, and the SES and education system in China. It answers the third research question: What are the experiences of female engineering students at universities in China? The chapter concluded by presenting recommendations from participants regarding what undergraduate engineering programmes could do to enhance support for female students.

Gender segregation persists in undergraduate engineering programmes at Chinese universities. Being marginalized in social interactions with male classmates, the participating female engineering students generally feel powerless in meeting their social needs. Although several positively evaluated their social lives at university, it is important to note that such perceptions are often built upon psychological sacrifices and gender essentialism. Both gender crossing and gender dualism were observed among the participating females. They are currently in the middle space between traditional Confucius values and an emerging feminism and women's consciousness-awakening in China. Besides this, a sense of pride in being an engineering major is identified to enhance the engineering subjectivities of female students, even if this subjectivity does not necessarily result in a career inside engineering.

The gender segregation can be exaggerated by gendered practical task assignment and gendered assessment at university. Lacking practical opportunities in fieldwork activities and engineering skills competitions, which is out of the 'care' of university teachers and their male classmates, can contribute to the low self-efficacy and interest of some female engineering students. Lower assessment standards on some practical tasks for female students would further undermine their self-efficacy in engineering. Moreover, existing assessments overemphasize written knowledge while neglecting the evaluation of practical skills. This may push more female students to memorize textbooks as they are socially expected to be better at memorizing than male students. Consequently, female students in my study often achieved higher grade but lower self-efficacy, because they attribute their academic success to the rigid memorization of textbook knowledge, rather than a deep understanding of engineering principles and mastery of practical skills.

As outlined in participants' narratives, the influence of family SES on their university experiences seems to be limited. This might be because, in China, undergraduate students commonly live in dormitories on campus, far from their homes and parents. Their interactions with parents are hence much reduced compared to their experiences during pre-university schooling. Additionally, it is observed that students from rural areas tend to receive much more diminished support from their families due to the possession of limited cultural capital, especially in the field of engineering. The next chapter explores the intersecting aspects of gender and SES to explore the career choice processes of the sample female engineering undergraduate students.

Chapter 9 Career choice processes of female engineering students

Having explored the elements of institutional culture that affect the social and learning experiences of female engineering students at university, this chapter explores factors associated with the career choice stage, including internship experiences, discrimination in the job market and career-related gender norms. Family habitus and engineering capital are also argued to be important aspects in shaping female students' agentic negotiations with social gender norms. Finally, the chapter includes observations relating to a lack of ambition among participants who had already chosen or planned a career in engineering.

As I have claimed throughout this thesis, female students' continuous past experiences can shed lights on individual career choices. The gendered social structures, family SES background, pre-university experiences and university encounters will also be drawn on when analysing their career choices.

9.1 Internship as an augmentation

Internship experiences in engineering can serve as a precursor to the actual workplace environment and can influence one's willingness to pursue a career within the engineering field. Nevertheless, in this study, six participants (out of 24) reported that they were unable to undertake any internship opportunities due to the Covid-19 lockdown scenario. This is acknowledged as a limitation of the research. Apart from force majeure brought about by the virus, only seven participants worked as interns in engineering positions, including both on-campus and off-campus experiences. This resonates with the quantitative data and indicates an issue within the Chinese higher education system where students face a deficiency in practical opportunities in terms of working places to apply knowledge acquired in the classroom.

On-campus internships are often facilitated by universities themselves, while off-campus internship positions need individual efforts to secure. In addition to individual competency, both gender and SES were reflected in the process of finding an internship position. For example, Li (outside engineering) said that, ‘Without my family members’ social network, I could not find an internship position in such a good company. I was not eligible as an undergraduate student and they preferred males actually’. Explanations regarding Li’s choice of leaving engineering are detailed later in the section.

Among these seven participants, the majority (N=5) expressed a reduced inclination to pursue a career within engineering after completing their internships, aligning with the quantitative results. The interview participants provided me with a more comprehensive understanding of the mechanism behind the numerical relationships. In most cases, it is the working conditions that contribute to the attrition of females in engineering:

> Our internship was visiting workshops and engine factories. After the visit, I was determined to take the postgraduate entrance exam and switch to a different programme because of the harsh environment in those factories. The ground was really covered in oil stains. I did not know how to step on it. My umbrella accidentally fell. I immediately picked it up, but the top was oily. I felt overwhelmed at that moment. (Mai, outside engineering)

> Computer-related work usually requires a complex environment setup, and I felt that back-end coding wasn’t suitable for me. I spent two days trying to set up the environment for the code, but I couldn’t get it right, so I decided to leave. I did not want to just sit there every day, silently face the computer, deal with all kinds of bugs that I couldn’t fix. Everyone else had their own things to do, and I felt very isolated and helpless, so I did not want to stay there. It felt like a new kind of mental prison. (Ren, outside engineering)

When experiencing actual work within engineering, Ren found that she could not stand the isolated working environment and challenging tasks, while Mai resisted the dirty working conditions. Internships might lead students to doubt whether they would fit into engineering work culture (Seron et al., 2016). For them, these aspects could be regarded as an extension of the university experience elaborated earlier, and as the last straw that broke the camel’s back, compelling them to exit this field after graduation.

Diverging from the perspectives of those female participants who vocalized the adverse effects of their internship experiences on career aspirations, Xiao exhibited a more positive stance when she initially talked about her internship encounters. Nevertheless, it was perceived by her more as a means to deepen her knowledge reserves in a different and more useful direction, rather than as a promotion of her engineering career aspirations:

> I learned a lot of essential things through internship, perhaps not a significant improvement in technical skills, but what I observed is really different from what the university teaches taught us. I gained a foundational concept for the development of certain enterprises, and I feel like I can adapt more quickly than others. (Xiao, inside engineering)

However, Xiao later revealed that working as a programmer is boring by observing that, ‘At that time, I felt that although the working atmosphere was quite simple and good, it was really boring. I would sit there all day, not saying anything, just typing codes, and then leave when the work was done at the end of the day’. When I asked her why she still chose this career, she said: ‘The job market is tough, so finding any job available is sufficient. There isn’t much room for selective choices’. This statement highlights two things: intense competition in the job market; and a lack of foresight and vision regarding her chosen career. These two points arose in many participants’ narratives and will be elaborated upon in the following sections.

The other participant whose internship did not drive her out of engineering was Yang (inside engineering). Instead, her internship made her realise the necessity of further study in this field if she wants to achieve something innovative, rather than engaging in repetitive tasks. Reflecting on her schooling and family background, Yang was passionate about conducting chemistry experiments at school and her father provided her with a high level of engineering cultural capital. She thus possessed high level of interest and self-efficacy in her undergraduate programme of materials science and engineering. By recognizing herself as an engineering person, she also aimed to contribute something to national development out of a sense of patriotism. It is worth noting that patriotism is significantly ingrained and emphasized within the Chinese education system (Law, 2014), further influencing individuals like Yang in their pursuit of academic and professional endeavours. Yang was well-equipped with the engineering-related aspects mentioned above. In this context, an internship can serve as an opportunity to consider what steps she needs to take to better fulfil her ambitions in the field of engineering.

In summary, internships often serve as an augmentation of existing perceptions and experiences for female students, enhancing their previous thoughts and understanding of engineering and engineers. For example, if they are concerned about a hash work environment or other difficulties, such as stains; if they are eager to improve themselves, they may view internships as a way to find potential solutions to overcome these challenges.

9.2 Gender discrimination in the job market

All the interview participants expressed, regardless of what they had heard from others or experienced personally, they had concerns about perceived gender discrimination in the engineering job market. At times, these biases may be invisible and well-concealed, but unfair recruitment practices targeting female engineering students do exist to a significant extent (Xu & Yu, 2013). The discriminatory practices identified in the interviews involve an inherent gender advantage favouring males during recruitment, more stringent requirements for female candidates, divergent job assignments based on gender or their perceived abilities associated with gender, and limited promotion opportunities for women.

Such discrimination against women can be attributed to entrenched gender norms in Chinese society. Women’s bodily features such as relatively smaller bodies, menstruation and pregnancy are also regarded as excuses by my interview participants to explain women’s underrepresentation in the engineering field, and employers’ potential discrimination against women jobseekers. Instead of trying to find a way out, most were inclined to accept the situation and labelled themselves as being less capable to handle heavy tasks. Rui (outside engineering) even claimed in a fairly straightforward way that: ‘because he is a man, whose innate physical capabilities and strength are naturally better than women’s. This is an objective issue that cannot be changed’. Gender essentialism is evident in her statement. She also admitted that she had tried to develop other competencies to compensate for her physical weakness. However, it appears that employers do not prioritize these competencies; instead, they simply require the physical strength needed for construction site work. Gradually, she decided to hold out a white flag to the constructions of social structures and gave up her civil engineering programme. According to my participants, physical strength is often more important in traditional engineering sectors, such as construction, manufacturing, and energy, leading to more severe gender discrimination in those sectors. Section 9.6 talks more about different engineering sub-disciplines.

Rui’s negative perception towards physical strength is representative of most of my participants, only one of whom emphasized that women’s agentic endeavour could change this apparently stable structure: ‘if women are willing to invest time in improving their body strength, I believe they can also compete with men’ (Xin, inside engineering). Xin’s statement indicates a post-structuralist perspective that the body can be shaped by daily exercise and eating habits so that men’s apparently perpetual physical strength can be challenged. The way individuals are raised from childhood is gendered and girls are not encouraged to be physically active (Cowley et al., 2021).

In addition to physical strength, menstruation was frequently mentioned by participants as a concern for employers. Hou (outside engineering) mentioned, ‘Working on certain construction sites with a desolate environment can indeed be inconvenient for women when they are menstruating, as being outdoors can give rise to problems, especially when it comes to restroom access'. Thus, she argued that less physically demanding, indoor jobs are more suitable for women in engineering. Those issues associated with women's bodies are not natural or unsolvable, but patriarchal societal norms and capitalist economic systems might not prioritize addressing women's needs such as consciously increasing restroom access for women on construction sites.

Furthermore, 13 out of 24 participants mentioned, by drawing on their experiences or what they heard from friends, lectures or seniors, how the issue of pregnancy and maternity can make women engineering students less preferred by employers and can lead to encounters with the 'glass ceiling'. Gender discrimination in engineering unfairly restricts women's opportunities, and their abilities are overlooked as they usually do not even get the chance to be interviewed.

It is noteworthy that some female participants exhibit understanding towards employers' biased practices. For example, Mu said: 'After all, due to the physical and reproductive reasons associated with females, they may not be able to participate in many field projects with high efficiency. The company's practice in this regard is quite normal and understandable, as every company wants to make money'. This reflects an inherent and subconscious belief among the students that, as females, they may bring inconvenience or fewer benefits to a company. This resonates with the findings of research on work-life conflict conducted by Williams (2018) that found mothers and prospective employees tend to blame themselves, rather than their employer, for the intense work-family conflict they experienced. Meanwhile, Confucian education towards females in China could reinforce their supposed traits of being so understandable and unselfish.

Female engineering students become aware of gender discrimination in the engineering job market even before they start to seek a job. As Chen (outside engineering) said: 'From the very first year of university, I began to hear about the unfairness in employment, shaping my self-expectations to the point where I felt uncertain about finding a job within the field of engineering'. Ongoing pressure from external society can contribute to an escalation in the psychological burden. Given the power dynamics between job seekers and employers, these students may perceive themselves as powerless to resist such discrimination. When they reflect on their inner conversations, they might identify internal barriers hindering them from being able to challenge these social constructs. Fu provided a good example:

> Facing such employment discrimination, I did experience more negative emotions. If employers are only seeking male candidates and not considering female applicants, it can lead to lower self-expectations of females. There may be a tendency for female students to feel that they might not be able to handle certain jobs, fostering a sense of self-doubt. (Fu, outside engineering)

Just two participants realized the existence of the norms and attempted to seek a solution to women's predicament. One considered the exercise of individual agency:

> Nearly everyone in our society still holds this notion that women should prioritize their families. It would thus be challenging to make progress. As a woman, to shatter these stereotypes, you need to work really hard and possess real competence. You must be significantly more excellent than your male peers. I mean, if you are only slightly better than a man, employers might still opt for the male candidate. (Ju, inside engineering)

Another participant talked about national childbearing policy:

> I believe the most significant issue lies at the national and policy levels. Take the recent policy shift to allow families to have a third child, for instance. I think it goes too far in treating women as mere reproductive machines, which is quite problematic. Employers might wonder if their female employees will leave work to have children and take care of them. Therefore, I believe it's essential for the government to focus more on directing more balanced educational resources toward women, rather than encouraging them to give birth to more babies. (Jin, inside engineering)

Ju's and Jin's opinions are based on similar logic of shifting women's energy and attention from family to self-development. They are conscious of the social structures at play, but they are not passive; instead, they try to understand and critically diagnose societal ills and respond in an agentic way with the intention to challenge them. Nevertheless, Ju emphasized individual agency, while Jin paid more attention to social structures. Ju's perspective highlights the additional efforts women must exert in a patriarchal society to receive equal treatment from employers. This resonates with the existing argument that numerous Chinese female engineering students are forced to choose a job outside this area or pursue higher academic qualifications to level the playing field with their male counterparts (Guan & Lian, 2016; Xu & Yu, 2011). In the latter case, qualifications can be an empowerment for women, though it is derived from gendered social structures. However, such a person-centred approach focusing on individual agency and development is usually criticised for being individualistic, neglecting the importance of addressing the unequal socio-historical structures (Gerlach et al., 2018).

Speaking of childrearing policy mentioned by Jin, the one-child policy from 1978 to 2015 in China has had profound social and cultural impacts on Chinese society (Xu & Woodyer, 2020). This family planning policy to some degree emancipated Chinese women from frequent childbirth and heavy domestic issues, allowing them to enter the job market. However, the implementation of the 'three-child policy' provides more difficulties for women in securing a job and getting promotions due to multiple periods of maternity leave. This policy was enacted to address the issue of the aging population in China, but on the other hand, it has created a new constraint on women's career development in Chinese contexts (Wu, 2024; Zhou, 2021). To counteract this side effect, more policy on supporting women's education and employment is needed.

In addition to the overall unfavourable atmosphere in the job market, in the next section, I illustrate how female engineering students negotiate parents' gendered perceptions of women's careers.

9.3 Negotiating parental discouragement over pursuing a demanding career

According to my interview participants, becoming a school teacher or a civil servant or any other public-sector jobs tends to be the most desirable career choice for parents in Shandong province, regardless of SES, when considering their daughters' futures. These jobs are considered to be stable, less pressured, but with relatively low salaries and repetitive tasks. As noted earlier, Shandong province is the hometown of Confucius, who emphasized women's value and role within the family sphere, so this preference is clear among my participants. Parental discouragement from pursuing a demanding career is identified as an important factor hindering female engineering students' choices of a career in engineering. Many participants conform to their parents' expectations and choose an easy career rather than becoming an engineer. Nevertheless, efforts had been made by some of my interviewees to oppose and challenge their parents' traditional influences.

Some participants attempted to resist those influences out of a rebellious attitude, but the resistance did not last long. For example, Cai's mindset was ultimately affected by her parents through their constant verbal communications after the temporary rebellious attitude against her parents' authority.

> They [parents] thought it would be great if I became a teacher because it is a stable and relaxing job, suitable for girls. My parents talked to me every day about taking the teacher certification exam during the first year of university. I had a strong rebellious attitude against them at that time and adamantly refused to become a teacher. I did not like it when people keep pressuring me to do something. However, as I matured and calmed down, I realized it might be a good option for a girl. (Cai, outside engineering)

There can thus be a time lag between constant parental verbal communication and its effects on their children. From Cai's account, we can see that she did not realize that her choice originated from the after effects of her parents' guidance during the past years. The instillation of thoughts through constant communication and interactions can gradually and even unconsciously shape how individuals exercise their agency to make choices (Goller & Goller, 2017). This can explain how agency is influenced by social structures, which impose invisible power on individuals. It can also explain why family habitus, cultural and social capital can result in children's gendered habitus and choices. Due to the constant and repetitive influence of her parents, Cai performed her gender script of being a traditional woman and chose a more humanities-focused master's programme, planning to pursue a career outside of engineering.

On the contrary, when Hee's parents expressed a similar hope to her, she managed to resist more completely because her aunt demonstrated a powerful role model, motivating her to keep learning and pursue a successful career, rather than opting for a stable and leisurely job for the sake of taking family responsibilities:

> I think it is because of the influence of my aunt, a rather independent and rich woman. She said that girls must have their own financial foundation and economic capabilities. (Hee, outside engineering)

Hee failed to be enrolled into her desired finance undergraduate programme because she did not perform well in her college entrance examination. She intended to retake that examination the following year, but her parents strongly opposed her idea because they think youth is important and valuable to women so there is no need to waste another year. She finally listened to her parents' advice and was accepted to an engineering programme that required a lower score. After graduation, Hee chose to pursue a master's programme in finance as she found learning engineering too boring and difficult. It is noteworthy that although she left engineering, finance also offers potential for lucrative career opportunities, empowering her as an independent woman in private and public spheres.

Economic empowerment of women has gradually become prevalent in Chinese society (Wang, Chan & Abdullah, 2024). Most of my interviewees emphasized the importance of financial independence for women, although many were reluctant to engage in demanding jobs to earn money. They tended to believe that women do not need to earn as much money as men but should earn some money to at least support themselves to attain status in their future family. This can be interpreted as the result of the intersection of Confucianism and feminism in the current transformative stage of social development in China.

Li was the only participant whose parents harboured an anti-gender bias mentality:

> They don’t even believe that women are inherently weaker than men, so in my upbringing, they never implied that being a girl meant I couldn’t do certain things or that I should strive for an easy and stable career and life. On the contrary, they felt that as a girl, I should be able to endure hardship, be strong, and persevere. (Li, outside engineering)

Li demonstrated a profound understanding of gender norms and feminism throughout our interview, which may be attributed to similar thoughts held by her parents acting as powerful guides and proxy agents. In this case, it seems that she did not need to struggle like Cai and Hee when negotiating powerful gender norms. However, her career choice lies outside of engineering despite the liberty she enjoyed in her family. Her parents insisted on breaking gender stereotypes by pushing her towards the engineering field, despite her personal preference in learning foreign languages at university. Hence, she struggled in learning engineering at university, which ultimately led her to pursue a path outside of the field. Parental power and patriarchy are still evident in this case, limiting Li’s agency in making her own subject choices. Therefore, the optimal outcome is not that women must perform against gender norms, but rather that they can freely make their choices without being confined by gender norms. A similar aspect mentioned by Diee (inside engineering) was that rather than making a hasty judgement that women are unsuitable for engineering, it is preferable to allow individuals an equal chance to explore any field before they make a decision about whether they are suitable for it. Family members can be critical in supporting and enabling such agency to make free choices.

Beyond the social-cultural discouragement of a demanding career on women, Mo talked about the issue of gendered roles from the perspective of men, which actually reflects on how men are also treated unequally because they are under huge pressure to earn money even at the cost of their health:

> I think that men's pursuit of salary is stronger than that of women, because salary in the engineering field is higher than in liberal arts fields […] Girls will not engage in tiring fieldwork or high-intensity manual work for high salaries, but men will. Comparing salaries, men tend not to regard health issues as important as girls do. (Mo, outside engineering)

Although Mo did not go into further detail in this regard, her statement suggests a question: are men really willing to sacrifice their health in exchange for money to support their families? Society places a heavy financial burden on their shoulders that in some cases weighs them down. Evidence shows that men experience poorer mental and physical health conditions than women with similar social background (Evans et al., 2011). Masculine gendered norms can do harm to both men and women (Connell & Messerschmidt, 2005). In the field of engineering, although it is a lucrative industry, it often requires long working hours in a hostile working environment. This can lead to adverse effects on men, who are the dominant workforce in this industry. Though men are the oppressors in a patriarchal society, they are unable to liberate themselves because they have to work hard to maintain their dominant position and power. Thus, Freire (2020: 44) observes that the 'great humanistic and historical task of the oppressed: [is] to liberate themselves and their oppressors as well'.

9.4 Leveraging engineering social capital to empower female engineering students

In addition to the career-related gender norms articulated in the previous sections, family engineering social capital tends to be instrumental in assisting female engineering students in this study to pursue a career in engineering. For example, Xiang's family members, as female role models, inspired her to continue with engineering as a career after graduation:

> My cousin's aunt works at an engineering design institute, which is a job with relatively high social status. I forget whether she has a master's degree

> or not, but she worked very hard, and there were many 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 in finding a job as a structure designer in an engineering design institute, when she was struggling with getting a master's degree offer and the discrimination towards female job hunters in this industry:

> It was my dad and my cousin who helped me find this job. 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, with my university background and 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 do you then have the chance to be accepted by this institute. (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. This resonates with the findings of Madara and Cherotich (2016), who suggested that having an engineer in the immediate family (engineering social capital) has a positive influence on perceptions of engineering and thus supports interests in pursuing engineering as a career.

However, some participants did not recognize the significance of social capital and rarely contacted relatives working in the engineering field during their undergraduate years, such as Hou (outside engineering) and Cai (outside engineering). When they encountered difficulties in academic study, personal life and employment, they seldom considered seeking help from their engineering social capital. Hou explained her reason as: 'Actually I am not very familiar with them. We seldom connect with each other except for the yearly Spring Festival gathering'. It might happen in some Chinese families that they live with a nuclear family and have distant relationships with extended family members. In this case, even though some female students have engineering social capital in their extended family, they do not consciously keep in touch with them.

In addition to engineering social capital within their families, university teachers are acknowledged as crucial figures embedding engineering social capital within the university environment, significantly influencing students' perceptions and interest, and shaping their career aspirations in engineering. University-based engineering capital can compensate for a disadvantaged family background. Jin, despite being from a rural background with scarce family-based engineering capital, developed close relationships with her university teachers. With their assistance in study, she cultivated an interest in engineering; and with their emotional support, she persisted in this field:

> However, throughout my entire four years in university, I did encounter many excellent professors who provided me with a lot of assistance in study and emotional support. They made me think that it's actually quite an interesting field. At some point midway through, I was tired of this industry. However, encouragement I received from them during that period changed my perspective on this industry. (Jin, inside engineering)

Yang, having limited family engineering capital, developed a strong relationship with a female lecturer and a female master's student under the supervision of this lecturer. Later, she was involved in a small engineering project led by them. She received concrete help from this senior female master's student and cultivated an interest in engineering. She said: 'If I hadn't actively reached out to this lecturer, I would be like other students, lacking practical opportunities under the lockdown situation due to Covid-19'. Additionally, she was encouraged to move forward in the engineering field by another female faculty acting as a role model for her:

> In our department, there is a female professor. She holds both master's and doctoral degrees from Tsinghua University, and she also had postdoctoral experience in Germany. She gives me the impression that she does not need to rest and works even during summer and winter vacations. She works even harder than male teachers. I find it very impressive and admirable. I aspire to become a faculty member like her. (Yang, inside engineering)

Regardless of gender, STEM talent/faculty who received education from top Chinese universities and have had overseas postdoctoral experiences can be a source of engineering social capital. When these individuals are females, the effects on female engineering students can be more pronounced due to ally-building illustrated in Section 8.1.2.

There is evidence that the prestige of a doctoral degree's awarding university can be one of the main influencing factors on academic recruitment, especially at top universities (Bedeian et al., 2010; Canavan, 2014; Mai, Liu & González-Bailón, 2015). Hence, better universities would be more likely to hire these talents. Besides, more prestigious universities would recruit students with higher academic achievements who could also be a source of engineering social capital as peers and seniors in the same major. Furthermore, top universities tend to provide more support with research and related infrastructure establishment, which can embody a higher level of engineering cultural capital. Xiang (inside engineering), from a second-tier university, mentioned her experience of attending a national engineering competition. She used Tingshua university and Tongji university (both top universities listed in the 985 project) as examples to describe her admiration of how top universities have better teaching resources and funding support:

> Their supervisors place a high emphasis on engineering research, and they are willing to invest money in refining projects, providing students with ample research funds, and hiring experts from outside to help students correct errors in their projects. (Xiang, inside engineering)

The above-mentioned participants all had limited family-based engineering capital, while Yu (inside engineering) had a high level of both family-based and university-based engineering capital. She was deeply influenced by her parents, who ran a machinery repair shop when she was little. And her interest towards engineering was further cultivated by a university teacher. She said: 'I get along well with the lecturer in the engineering drawing course. I appreciate his teaching style, as he has a way of presenting lectures that turns boring terms into something interesting and vivid'. Yu was from a 985 project university, which could offer her greater social engineering capital. With a high level of family engineering capital and a positive relationship with university teachers, Yu aspired to pursue a PhD in mechanical engineering and become a skilled professional in the field of engineering. In this case, the two fields of family and university could enhance each other in terms of engineering capital. Yu stood out as the interview participant who expressed the strongest aspiration to achieve significant accomplishments in the field of engineering, especially since the field has made itself unappealing to many female participants.

9.5 Lacking expectations to be an excellent engineer

Among the 24 interview participants, four had secured positions within engineering sectors and 15 had chosen engineering post-graduate programmes. Although the total number may sound high at 19, it is essential to note that, out of the 15 participants in the engineering master's programme, eight expressed plans to work outside the field of engineering. Even for the four female engineers, engineering does not appeal to them enough to inspire a strong ambition to excel as engineers or make significant contributions within the field. Further qualitative analysis in this section explores the factors contributing to this observation.

9.5.1 The illusion of choice in postgraduate programmes: apparently optional, yet ultimately limited

It is notable from the participants' narratives that their undergraduate lives were marked by notable struggles and dilemmas, including the lack of a sense of belonging, lack of practical opportunities, gendered assessment, and perceived gender discrimination in the engineering job market. In this case, when selecting a master's programme, there is an opportunity for them to transit away from engineering disciplines. However, among the 18 participants who pursue a master's degree, only three made such a decision to discontinue their engagement with engineering. Eight participants planned to leave engineering after obtaining a master's degree in this field. Therefore, when they could make a choice to end their struggles and ambivalence, these females exhibited hesitancy in embracing such a decision. A common justification for their choices was that securing a master's degree is more significant than choosing a programme they might interested them. This is significantly affected by the trend of 'educational inflation' in China where a master's degree has become the choice for more and more undergraduates (Liu, 2018). Enrolling in a master's programme becomes more achievable when pursuing a similar programme as the undergraduate subject. In this case, even if some participants intend to leave this area upon securing a job, they still choose to learn engineering for their postgraduate studies. Below are some selected examples:

> China's job market is too competitive. The devaluation of academic qualifications is severe. Everything was on the premise that I could be accepted as a postgraduate student. I did not have much loyalty to the choice of subject to learn, as long as I could be enrolled. (Ren, outside engineering)
>
> 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 postgraduate entrance examination. (Hou, outside engineering)

Therefore, to secure a master's degree, they make another choice of self-suppression, similar to the decision they made to accept 'tiaoji' four years earlier. This can be interpreted as agentic conformity to the educational social structures in Chinese contexts. Their decision to pursue postgraduate studies is not due to personal academic improvement. They lack a clear career vision while pursuing further education in engineering, indicating a new round of ambivalence in the next few years of postgraduate life. Although it seems that there are many options of master's programmes waiting for them, their decisions are constrained by the abovementioned social structures. It is worth noting that their career aspirations could change, subject to their experiences during their master's studies. Hence, further research on postgraduate-level students is recommended.

9.5.2. Engineering's inability to inspire strong expectations in female engineers

For those participants who had worked inside engineering or expressed an intention to work within the engineering field after education, most used passive language when describing their envisioned career trajectories. Xiao provides a good example:

> I now rely on it to make a living, so I must keep improving myself in this field. If you ask about my inner happiness, it's just so-so. I may not have a particular passion for a technical field; I just want to know how it's done and understand the principles behind it. I won't have a strong interest in it, but I rely on it for my livelihood. (Xiao, inside engineering)

Xiao's entry into an engineering position was quite coincidental; when submitting resumes, she did not clearly specify her intended position. She accepted the only offer she had at that time, because it was challenging for a female engineering student to find a job. However, based on her expressions, she exhibits low professional loyalty, and her work does not bring her joy. She is ready to leave at any time:

> In fact, I did not initially plan to continue working as a programmer; it was quite unexpected. But jobs were hard to find, and finding any job was good enough. Also, considering that I had studied something for four years, it felt a bit regrettable to throw it away. If I can do it, I would continue. Anyway, if not, I wouldn't have too many regrets to quite. After I joined the company, I started coding, and basically, I almost have no chance to speak throughout the day. It's really boring. (Xiao, inside engineering)

Diee explicitly stated that: 'I am not interested in engineering, so I don't want to study it. I just aimlessly finished my undergraduate education and looked for a job'. Due to professional constraints, she ended up choosing a career as an automotive welding process engineer. However, she soon encountered problems:

> I really can't stand working the night shift. The night shift starts from 8 pm until the next morning, and I feel that it's too detrimental to my health. Every day, I contemplate quitting. Whenever I see my classmates, I tell them I want to leave, really want to resign. But if I resign, I don't have work experience, and no one will hire me. Later, I might consider taking a civil

service exam just as my parents suggested. (Diee, inside engineering)

Diee had grown weary of studying engineering due to low interest, low self-efficacy and lack of belonging. She attempted to apply for a master's programme in law, but was unsuccessful. Due to limited economic capital in her family, she could not afford to study for another year to retake the postgraduate entrance examination. Consequently, she chose to find a job. Also, in the future, she planned to become a civil servant, a stable job that her parents regarded as suitable for women.

It can be seen that these females lack passion for working in engineering even when they end up being engineers. Their current persistence in the engineering domain seems to align with the philosophy of 'taking each day as it comes'. They have not exited this field, possibly because they are awaiting a suitable opportunity, or it could be that they have not reached an age where they feel brave enough to make such a pivotal choice. It may represent an agentic compromise to current societal norms.

Compared to participants who directly enter the workforce in engineering, the eight participants who pursued further studies in engineering and planned to work in the field seemed to demonstrate a slightly greater ambition and determination to achieve something in this field, though not much more. And most possessed certain levels of engineering capital. If individuals aspire to accomplish notable feats in a specific field, further study is often seen as an important and strategic step. For instance, Ju (inside engineering) said that: 'In undergraduate studies, to be honest, I haven't learned a lot. Therefore, I want to pursue further education to enhance my ability in engineering'. Yang (inside engineering) expressed a similar idea that: 'I feel that undergraduate study merely opened the door for me. I believe I need to pursue postgraduate studies to delve deeper into this field. It's also to contribute more effectively to the construction and development of our country in the future'. Attaining a higher education level in engineering could help to reduce the attrition rate among female engineers to some degree. It is suggested that further studies explore the influence of education degree on the attrition of female engineering students.

9.6 Different engineering disciplines

It is noted that engineering disciplines are not homogeneous. Different disciplines have distinct learning content, approaches, working environments and varying levels of difficulty. Females in some engineering subjects that traditionally have more females, such as food science and engineering, material engineering, and industrial design and industrial engineering, would find it easier to fit in and acquire knowledge. Normally, these subjects do not require physical strength or spatial imagination, which are traditionally regarded as male advantages. For example:

> Studying food science and engineering as a female is relatively relaxed. In our programme, the gender ratio is around 2:1, with twice as many female students as male students. In terms of the production process, I think it's manageable because it does not require much physical strength […] During my internship, we visited the research and development lab of a food company. It seemed that most of the personnel conducting experiments and analyses in the lab were female. (Ju, inside engineering)

> In our materials industry, there is quite a demand for women, especially in roles like quality inspection, where women are generally preferred because they are perceived to be more meticulous and careful compared to men. Moreover, contemporary chemical plants and materials factories prioritize environmental sustainability, ensuring a very clean and tidy working environment. (Mu, outside engineering)

Differences in prosperity and compensation across certain engineering disciplines were also identified by interview participants. Traditional engineering industries such as mechanical engineering, mining engineering and civil engineering are not as prosperous and high-paying as emerging industries, such as software engineering and computer science and technology. However, this thesis does not delve further into a detailed comparison between these engineering disciplines due to the limited number of participants, which does not provide enough data for these different engineering disciplines. This is acknowledged as a limitation of this study and should be addressed in future research.

9.7 Summary

This chapter explored how gender and SES intersect to shape female engineering students' career choices regarding internship experiences, employment seeking, negotiations with parental gendered expectations and engineering capital, as well as job ambition.

Internship experiences are argued to function as a reinforcement or augmentation of the pre-existing intentions that female engineering students have regarding whether to leave or continue in the field of engineering. Gender discrimination in the job market and stereotypical beliefs about less demanding careers held by parents hugely distance female students from this domain, but with the help of engineering social capital, some participants have been able to secure job positions within the field. It seems that family SES exerts limited influence on their university lives due to the considerable physical distance between the universities and their homes. However, university-based engineering capital can serve as a supplement for those with lower levels of family engineering capital, and as an enhancement for those with higher levels of family engineering capital. Learning engineering and participating in various engineering-related activities at university can be regarded as a form of engineering cultural capital. Engaging closely with peers and faculty members can help develop university-based engineering social capital, serving as role models, guides and instructors who can support female engineering students to pursue a career in this field. More prestigious universities tend to have more potential to provide their students with a higher level of university-based engineering capital.

When it comes to career choices, there is a notable absence of ambition and expectations for success in the field of engineering, even for those choose a career inside engineering. This can be attributed to a forced pursuit of engineering to secure a master's degree due to the effects of 'education inflation', and an accumulated dissatisfaction towards engineering stemming from the four years of undergraduate education. It indicates that under the current education system and social-cultural background in China, even if several females do enter the engineering job market, it does not necessarily translate into self-fulfilment within the profession, nor is it a sign of success for women in STEM.

Career choices may seem like decisions made in an instant, but they are actually based on the accumulation of long-term efforts and experiences. Therefore, this chapter can only partially answer the fourth research question: How do gender and SES intersect to shape the career choices to continue in or leave engineering of Chinese female engineering newly graduates? A comprehensive understanding of career choices should organically integrate the findings from all three qualitative chapters. Family engineering capital and the Chinese educational system can make a difference in mitigating the effects of prevailing Confucian gender norms, promoting these female students entering engineering undergraduate programmes. This dynamic interplay also leads to different strategies employed by sample female students in exercising agency to deal with challenges encountered within the gendered environment of engineering programmes. At the career choice decision-making stage, female students face pressure from both the job market and their parents' gendered expectations. However, leveraging university-based engineering capital is argued to be empowering for female engineering students, in particular for those from rural areas and with limited family-based engineering capital. A more comprehensive and synthesized discussion and conclusion is presented in the next chapter.

Chapter 10 Discussion and conclusion

This study employed a mixed-methods approach to explore the experiences and career choices of female engineering undergraduates at Chinese universities. The survey targeted year one to year four male and female engineering undergraduate students at universities in Shandong province, China. The semi-structured interviews engaged newly graduated female engineering students from universities in Shandong province. Social structures, including gender, SES and education system in China, provide mixed constraints and opportunities for female students in engineering undergraduate programmes who agentically negotiate and respond to these social structures. This chapter combines the discussion and conclusion together, to provide synthesized and rigorous answers to each research question. The reconceptualization of 'engineering capital', motivations to choose engineering programmes, university experiences, and career choices related to the four research questions are addressed. The chapter then discusses the practical implications of this study, followed by limitations of the research and corresponding suggestions for future research. Finally, a summary section recapping the key and important findings and arguments of this research is provided.

10.1 How is science capital manifested in engineering disciplines in Chinese higher education?

'Engineering capital' is regarded as SES related to engineering in this research. It intersects with gendered structures in shaping the experiences and career choices of female engineering undergraduate students at Chinese universities. Clarifying this concept at the beginning of this chapter helps to obtain a clearer understanding of discussions and conclusions related to the other three research questions. As a potential theoretical contribution of this research, 'engineering capital' is conceptualized in this section as the manifestation of 'science capital' in engineering in Chinese higher education contexts. University-based engineering capital is a new addition. Justifications and the conceptualization are provided in this section. Table 10-1 illustrates detailed dimensions of ‘engineering capital’ discussed later in this section. The concept of ‘gendered engineering capital’ is also proposed to unveil the problematic nature of this concept, which serves as an alert and reminder to future research when adopting this approach to empower women in engineering.

<table>
<tr><th>Concept</th><th>Dimensions</th><th>Pre-university</th><th>University-based</th></tr>
<tr><td rowspan="4">Engineering capital</td><td>Engineering social capital</td><td colspan="2">1. Knowing someone who works/studies in engineering
2. Talking to others about engineering
3. Parental engineering qualifications
4. Parental engineering interest and capability</td></tr>
<tr><td rowspan="2">Engineering cultural capital</td><td colspan="2">1. Engineering literacy
2. Symbolic knowledge about the transferability of engineering in the labour market.
3. Engineering habitus
1) Future engineering affinity (interest, self-efficacy and admiration to engineering and engineers)
2) Engineering subjectivity (the sense of whether engineering is ‘‘for me,’ and sense of pride of being an engineering major)</td></tr>
<tr><td></td><td>4. Engineering curriculum, pedagogy, mentorships, experiments, assessments and other related educational infrastructure establishment</td></tr>
<tr><td>Engineering-related behaviours and practices</td><td>1. Consumption of engineering-related media
2. Participation in out-of-school engineering learning contexts.</td><td>3. Interactions with engineering faculty members and seniors/peers in the same major to seek support in engineering study and career
4. Participation in university-based engineering learning and practical contexts</td></tr>
</table>

Table 10-1 Engineering capital

10.1.1 Reconceptualizing ‘science capital’ in my research

‘Science capital’ as presented in Chapter 2 is a concept describing science-related forms of capital and habitus that was developed by Louise Archer and her team. Existing rationales for utilizing science capital as a theoretical lens tends to focus on school-aged students in the UK, with a particular emphasis on predicting their post-16 science participation and aspirations (see Archer et al., 2012; Archer et al., 2015; DeWitt et al., 2016; Moote et al., 2019a; Moote et al., 2019b). This concept has been widely adopted and substantiated by existing research in predicting aspirations in science and STEM fields (see Ceglie, 2021; Cooper & Berry, 2020; Rüschenpöhler & Markic, 2020; Williams & Choudry, 2016). More recently, the focus has begun to shift towards 17/18-year-olds and undergraduate-level students, expanding the application of science capital to the broader STEM domains (see Holmegaard et al., 2024; Godec et al., 2024; Moote et al., 2020). However, there is a lack of application and adaptation of this term in the Global South, including Chinese contexts, even after Du and Wong (2019) argued in a quantitative study that science capital better predicts the science career aspirations of 15-year-old UK students than those of Chinese students. To date, the career choices of Chinese engineering students after graduation have not been explored from this theoretical perspective. Hence, my study aimed to address these two limitations in the current development of ‘science capital’.

This reconceptualization from ‘science capital’ to ‘engineering capital’ is mainly justified by conclusions from two of the abovementioned studies by Archer’s team: 1) Students’ post-compulsory study aspirations of engineering are strongly related to science capital (Moote et al., 2020); and 2) Both science capital and STEM identity (a shorthand descriptor of the four disciplinary identities/subjectivities) are positively associated with participation in a STEM undergraduate degree (Godec et al., 2024). However, science capital has a weaker association compared to engineering attitudes (Moote et al., 2020) and STEM identity (Godec et al., 2024). The first conclusion confirms the potential of applying science capital in the field of engineering. The second offers an opportunity for university-based engineering capital to take effect, as the ‘science capital index’ (Archer et al., 2015) applied in their research was designed for pre-university students. I suggest that science/STEM capital embedded within universities can help bridge the association gap between science capital and STEM subjectivities in higher education contexts identified by Archer and colleagues.

In recent years, efforts have been made to adapt ‘science capital’ to more specific or extended disciplines. For example, Cannaerts and colleagues (2023) adopted ‘engineering capital’ to investigate its relationship with gender and migration background, as well as aspirations and performance within the engineering technology field of secondary school pupils and engineering university students in Belgium. Luo and colleagues (2024) validated the instruments of ‘STEM capital’ among primary and secondary students in Hong Kong, China. Nevertheless, their conceptualization of ‘engineering capital’ and ‘STEM capital’ mainly transfers ‘science’ related aspects into ‘engineering’ and ‘STEM’, and considers only pre-university experiences, while my study aimed to provide more comprehensive and culture-sensitive methodological and theoretical reconceptualizations of ‘engineering capital’ in Chinese higher education contexts.

When it comes to the data collection and analysis of my research, I have two more rationales for adopting ‘engineering capital’ rather than ‘science capital’. First, the cognitive interviews (see Chapter 5) suggested that the term ‘science’ tends to be broad and ambiguous in interpretation and is not commonly used in the Chinese linguistic context. Second, semi-structured interview participants usually mentioned engineering-specific capital, rather than science capital. Therefore, there is a need to develop a contextualized ‘engineering capital’.

This reconceptualization of ‘engineering capital’ is contained in two stages of the methodology. In the first stage, the survey, I adapted the original ‘science capital index’ into a ‘science and engineering capital index’ (see Section 5.2.3 for the localization of this index, and Appendix-II for both the adapted and original versions). As this is sequential mixed-methods research, when I designed the survey, I only aimed – through cognitive interviews – to use this Western-based instrument in Chinese contexts to measure pre-university science and engineering related capital. Nevertheless, in the second stage, the subsequent interview findings suggested the necessity to add a university-based dimension of engineering-specific capital, and some nuanced aspects of this concept, in particular for Chinese higher education contexts.

10.1.2 Engineering capital in Chinese higher education contexts

This study reconceptualizes ‘engineering capital’ as a conceptual tool not only for understanding the classed patterns in engineering, but also for empowering disadvantaged groups in this domain. The general definition of ‘engineering capital’ is similar to ‘science capital’ (Archer et al., 2015): engineering-related forms of social capital, cultural capital and habitus. Economic capital is also regarded as a potential approach to increase engineering capital, such as purchasing more resources and opportunities to acquire engineering capital (Archer, Dewitt & Willis, 2014), since the survey data confirm that engineering students from urban areas possess a statistically significant higher level of ‘science and engineering capital’ than rural students. The quantitative results of this study also show that the sample university engineering students obtaining a higher level of ‘science and engineering capital’ were more likely to have a career choice inside engineering. However, I have different interpretations of this concept and its specific manifestations in Chinese higher education contexts.

10.1.2.1 University-based engineering capital

First and foremost, ‘university-based engineering capital’ is identified as an important aspect of ‘engineering capital’, shaping the career choices of continuing in engineering among Chinese female engineering undergraduates. Archer’s ‘science capital’ involves three main categories: 1) scientific forms of cultural capital (scientific literacy, science dispositions, symbolic forms of knowledge about the transferability of science qualifications); 2) science-related behaviours and practices (consumption of science-related media and participation in out-of-school science learning contexts); and 3) science-related forms of social capital (knowing someone who works in a science job, parental science qualifications; talking to others about science) (Archer et al., 2015). According to their interpretation, science capital predominantly originates from family, school, and media sources. All these can be translated into the engineering domain, but when applying it to the university field, an issue arose from the qualitative findings of this research. University students, as adults who usually live far from home, tend to have more distant relationships with their family and schoolteachers. Their direct influences are thus weakened dramatically (Zhou, 2016).

Instead, peers, faculty members, mentors, professional engineering organizations and university personnel become important alternatives as social capital, which can promote persistence and retention in engineering, especially for female students and first-generation students (whose parents never received higher education) (Brown, 2005; Martin, Miller & Simmons, 2014; Martin, Simmons & Yu, 2013; Martin 2015; Smith et al., 2021). Positive and frequent interactions with faculty were found to be positively related to the engineering self-efficacy of the underrepresented students in engineering undergraduate programmes (Dika et al., 2015). In addition to social capital, faculty mentoring was identified as a form of cultural capital that helps underrepresented engineering students achieve sustainable academic success (Chanderbhan-Forde, Heppner & Borman, 2012). Although there is little existing research regarding engineering capital embedded in university, the studies mentioned above evidence that these capitals can exist and can benefit female engineering students. Existing research focuses heavily on leveraging capital to widen women's participation in engineering/STEM undergraduate programmes (Cohen et al., 2021; Saw 2020; Skvoretz et al., 2020) and 'science capital' (Archer, 2015) has provided a solid theoretical foundation for empirical research at the pre-university level. When it comes to engineering higher education contexts, this study contributes to synthesizing the concept of 'university-based engineering capital', in order to build a theoretical framework for studies regarding engineering career choices of university students in China.

When considering the initial conceptualization of science capital, it can be seen that it is a concept for assembling various forms of capital that can enhance science engagement among children, and different forms of capital are noted to be sensitive to different fields:

> …We utilize 'science capital' as a conceptual tool for understanding the production of classed patterns in the formation and production of children's science aspirations. We propose that 'science capital' is not a separate 'type' of capital but rather a conceptual device for collating various types of economic, social and cultural capital that specifically relate to science—notably those which have the potential to generate use or exchange value for individuals or groups to support and enhance their attainment, engagement and/or participation in science…The meaning and value of a particular form of science capital will vary depending on who is possessing/ deploying it and in what context (field).
> (Archer et al., 2014: 5)

Bourdieu generated a formula to describe the interconnections among capital, habitus and field: '[(habitus)(capital)] + field = practice' (Bourdieu, 1984: 101). Bourdieu (2005/2000) highlighted that it is necessary to consider the social space/field where interactions occur to understand a social phenomenon. In the field of the university, engineering faculty members and seniors/peers in the same major become the social figures who possess engineering capital (Pfirman et al., 2014), thus they can be regarded as university-based engineering social capital. As have illustrated in Chapter 9, more prestigious universities tend to attract more faculty members and students of high engineering competency, demonstrating a higher level of engineering social capital (Canavan, 2014; Mai, Liu & González-Bailón, 2015).

Compared to the categorization of social capital identified by Archer and colleagues (2015), knowing someone who works in engineering is insufficient for measuring university-based social capital. This is because engineering undergraduates typically know a similar number of engineering faculty members and engineering classmates/peers, making it an inadequate metric for measuring variations in social capital in this context. Family-based engineering capital comes to individuals automatically and it can be a common practice for family members to give suggestions and provide influence for students, so that students exercise their agency to choose whether, how and to what extend accept or ignore these family-based capitals. But when it comes to the university field, students need to be more agentic and active to engage with and make use of the engineering capitals around them. Therefore, frequent interactions with engineering faculty members and seniors/peers in the same major to seek support in engineering studies and careers should be emphasized when considering university-based engineering social capital.

Developing close relationships with these figures is an agentic strategy for enhancing engineering social capital among university students. The interview findings of this study indicate that university-based engineering social capital, particularly through instructors and role models, can enhance engineering dispositions and choices. More importantly, for female engineering students, building an alliance with faculty members of the same gender can be more effective. It means that in addition to family-based engineering social capital, university students with lower levels of engineering capital at the beginning of university life can agentically develop their engineering social capital at university through their own social-networking efforts. However, it is noted that the gender monoglossic environment in engineering undergraduate programmes poses challenges to female engineering students to develop their university-based engineering capital (see Section 10.3), while at the same time, acquiring this capital can empower them to disrupt the gender monoglossia. Therefore, as illustrated in Section 10.3.1, it is essential for university teachers, as potential sources of university-based engineering social capital, to be gender-sensitive, thereby enabling better empowerment for female students.

Meanwhile, in addition to social capital, universities provide a cultural environment for engineering teaching, mentorships, experiments, assessments and other related educational infrastructure establishment, which can embody university-based engineering cultural capital. In this case, higher education institutions can make efforts to provide a more enabling environment for engineering students from disadvantaged demographic backgrounds, such as enacting more practice-oriented assessment to give students more and equal opportunities to practice their engineering skills (see Section 10.3.2). Considering the effects of economic capital, as have illustrated in Chapter 9, more prestigious universities, such as those listed in 'Project 985' and 'Project 211' , tend to provide more financial support for educational facilities and reforms (Jiang, Lee & Rah, 2020), which can embody a higher level of university-based engineering cultural capital. Therefore, from the university level, it can be predicted that students at more prestigious universities tend to have higher level of university-based engineering capital. Future research could examine this assumption and investigate other possible aspects, such as the prestige of engineering disciplines at universities.

In summary, the four-year experience of university for Chinese students can shape their engineering dispositions and engagement. The concept of 'university-based engineering capital' provides an inclusive approach for university students with lower family-based engineering capital to acquire capital through agentic practices, such as frequent interactions with engineering faculty members to seek support related to engineering and actively engaging in engineering-related learning and practical activities. This move can weaken the classed nature of engineering/science capital (Archer et al., 2014) and disrupt the reproduction of privileges in the engineering domain among white men from middle-class families (Archer et al., 2015). In addition, Holmegaard and colleagues (2024) argue that family-related computer science capital can facilitate early and stable aspirations towards computer science among undergraduates. Therefore, this study argues that to explore the engineering career choices of undergraduate students, it is necessary to consider both engineering capital accumulated before university and university-based engineering capital. It is noteworthy that all interview participants in this study claimed that their universities had no specific measures to assist female engineering students, marking an urgent gap that needs to be filled by higher education institutions in China. Finally, this study confirms that a larger proportion of engineering university students are able to obtain a high level of pre-university engineering capital, compared with the average pre-university students who have not decided on their university major.

10.1.2.2 A framework of pre-university engineering social capital from the Chinese contexts

Archer and colleagues (2015) define science-related forms of social capital (at the pre-university level) as: 1) knowing someone who works in a science job, 2) talking to others about science, and 3) parental science qualifications. This study suggests adding another dimension regarding pre-university engineering social capital, in addition to 3) parental engineering qualifications: parental engineering interest and capability.

Adding to Archer's definition, engineering social capital is not necessarily linked to parents who have a formal job or degree in engineering; instead, parents who are interested and capable in engineering practices can act as role models and provide chances for students to become familiar with engineering, as have illustrated in Chapter 7. In China, Confucianism emphasizing collectivist values such as submission to authority provides specific contexts for justifying the inclusion of this new dimension (Peterson et al., 2005). Due to the strong authority of parents in a typical Chinese nuclear family (Bi et al., 2018; Li & Lamb, 2012), the passing of an engineering-related power does not necessarily require formal qualifications to establish authority. Engineering principles are embedded in everyday life, so parents with strong engineering interests and capability can create opportunities for their children to engage in engineering and build interest from an early age. They can also provide engineering cultural capital and generate engineering habitus among students, which will be further discussed in the forthcoming section. Adding this new aspect of engineering social capital helps to explain those participants who do not have high engineering capital based on Archer's definition but develop engineering habitus and opt for an engineering career (such as Jin and Yang in Chapter 7).

Similar to Archer and her colleagues' (see Archer et al., 2012; Archer et al., 2015; DeWitt et al., 2016; Moote et al., 2019a; Moote et al., 2019b) findings in the science domain, this study reveals that engineering-related social capital within families can serve as influential figures shaping female students' interest in engineering from an early age, motivating them to pursue engineering at universities (Mannon & Schreuders, 2007; Miller, Martin & Orr, 2014). In addition, when it comes to pursuing a career or securing an internship in engineering, a new role that engineering social capital within the family can play emerges from this study. As further illustrated in Section 10.4.2, family members working in engineering can leverage their social networks to help students find internships and jobs within the field. In traditional Chinese culture, Confucianism places great emphasis on interpersonal relationships (Deng & Deng, 2016). Confucianism advocates five fundamental principles of behaviour, known as the 'Five Relationships': ruler and subject, father and son, elder and younger brothers, husband and wife, and friends (ibid). Under the influence of Confucian ethics, Chinese society can be described as a 'human society' that highlights the role of interpersonal relationships in obtaining resources and authority (Huang & Hu, 2010; Qu, Zhao & Zhao, 2021; Zhai, 2005). In this case, with the assistance of social capital within the family, female engineering undergraduates can be empowered to resist the gender discrimination found in engineering job recruitment.

Overall, a framework of pre-university engineering social capital can be established based on the Chinese contexts in this section: 1) knowing someone who works in an engineering job, 2) talking to others about engineering, 3) parental engineering qualifications, and 4) parental engineering interest and capability. Students actively participate in this process of engaging with those engineering social capital sources, but not all students with high levels of engineering social capital end up with an engineering habitus and career. It reflects the role of agency in interacting with different dimensions of engineering capital, which is further clarified in the next section.

10.1.2.3 Rethinking the relationship and weight among the quantitative dimensions of 'engineering capital' in Chinese higher education contexts

Archer and colleagues (2015) quantitatively categorize science capital into three dimensions. If translated into the context of engineering, these dimensions are: 1) engineering forms of cultural capital, 2) engineering-related behaviours and practices, and 3) engineering-related forms of social capital.

Engineering habitus/dispositions is included in 'engineering forms of cultural capital'. To clarify the meaning of engineering dispositions/habitus in this thesis: I consider dispositions and habitus to be interchangeable (Maton, 2014). In research by Archer and colleagues (2015), they use two dimensions to describe science dispositions (habitus) that can be shaped by science social and cultural capital: future science affinity (future educational and occupational science aspirations) and science identity (the sense of whether science is 'for me'). In the contexts of engineering higher education in China, as have illustrated in Chapter 7.3.2 and 8.1.4, 'future science affinity' can be further translated into 'future engineering affinity (interest, self-efficacy and admiration to engineering and engineers)'; and 'science identity' can be translated into 'engineering subjectivity (the sense of whether engineering is 'for me,' and sense of pride of being an engineering major)'. Engineering dispositions/habitus can be the results of acquiring engineering capital, while it also exists along with the accumulation of engineering capital. According to the interpretation of Reay (2004), habitus underpins cultural capital, leading to various manifestations of such capital. Therefore, the definition of engineering capital encompasses social capital, cultural capital and habitus, while engineering career aspirations are also regarded as a kind of habitus.

‘Engineering-related behaviours and practices’ can be a practical manifestation of ‘engineering forms of cultural capital’ and ‘engineering-related forms of social capital’. When designing the ‘engineering capital index’ (a post-PhD aspiration), the newly added aspect of university-based engineering social capital and cultural capital are mainly put under the dimension of ‘Engineering-related behaviours and practices’ (see Table 10-1). Meanwhile, in my view, obtaining an ‘engineering form of social capital’ usually means that one has an ‘engineering form of cultural capital’ that can be generated by social capital resources. Engineering cultural capital and habitus can be generated by engineering social capital, but not all engineering social capital can generate engineering cultural capital and habitus. Thus, some participants with engineers in their families still do not end up with an engineering career (for example Shi, Hai and Mai). Adding to Bourdieu’s perception that agency can be experienced through habitus (Dowding, 2008), this study further suggests that individuals exercise agency in the process of interactions between capital and habitus. Even exposed to a same level of engineering social capital, individuals can develop diverse habitus towards engineering due to their varying levels of agency. Therefore, among the three aspects, social capital could be the key to influence engineering dispositions/habitus, in which process this study argues that cultural capital and habitus play a more vital role in maintaining the sustainability of engineering career choices. For example, interview participants who secured a job as an engineer mainly because of the networks of engineering social capital within their family, rather than personal engineering dispositions, tended not be motivated to be excellent engineers and planned to leave this field several years later. As mentioned in Chapter 7, this reflects the potential limitation of quantitative investigation combining various aspects of capital into a single index.

10.4.2.4 Gendered engineering capital

Existing studies point out how fathers often have a larger influence on children’s science engagement and are often perceived as being more capable in STEM than mothers (Archer et al., 2012; Cian et al., 2022). Archer and colleagues (2015) also emphasize that males tend to have a higher level of science capital, but in their theorization and applications of science capital, they neglect that science/engineering capital itself can also be gendered and male-dominated. My survey results study suggest that fathers' highest educational level significantly affects the science and engineering capital level of engineering undergraduates, while that of mothers has no significant influence. The interview results indicate that in most cases, fathers, male schoolteachers and male university teachers contribute to affecting the engineering-related choices and perceptions of female engineering participants. Two factors might account for this: 1) males are stereotypically regarded by these female students as more authoritative and influential in STEM (Cian et al., 2022); and 2) engineering social capital itself is gendered and mainly possessed by males in senior generations (Mannon & Schreuders, 2007). University engineering programmes are also evidenced to have an underrepresentation of female engineering faculty (Fouad et al., 2017; Hill, Corbett & St Rose, 2010; Kulis et al., 2002). Overall, there is a lack of influence from female roles in engineering capital within family and educational settings. When engineering social capital is gendered, the cultural capital and habitus generated by social capital can be gendered as well.

The concept of 'gendered engineering capital' is proposed by this study. Realising the gendered nature of engineering capital is essential in conceptualizing it as a theoretical lens to measure engineering choices. As evidenced in qualitative findings, obtaining engineering capital can empower female students to disrupt the gendered norms that prevail in Chinese society. However, when the capital itself is gendered and problematic, without interventions, efforts to develop engineering capital can contribute to the reproduction of the gender structures in institutions. Therefore, I argue that when supporting female engineering students to develop engineering capital, these capitals need to be enacted in a more gender-sensitive manner.

Furthermore, in my research, I particularly identify the culture-sensitive nature of gendered engineering capital that is unique to the Chinese contexts. Though boys tend to receive more encouragement regarding STEM subjects from a young age (Simon et al., 2017; Tzu-Ling, 2019), due to the one-child policy in China, fathers who serve as major source of engineering social capital can empower their only daughters to learn engineering. It is thus essential to note from the perspective of intersectionality that engineering capital itself has the potential to both reproduce and subvert the male dominance in engineering fields in Chinese specific contexts. The previously mentioned 'human society' and strong parental authority also support these cultural forms. Therefore, this China-based study argues that research or interventions to support women in STEM or engineering also need to be culturally sensitive and consider specific cultural backgrounds.

At the end of this section, I summarize the answers to the first research question. As 'science capital' is a concept developed in the contexts of science, pre-university students and the UK, it cannot be automatically translated into the contexts of engineering, university students and China. This mixed-methods research provides the reconceptualization of 'science capital' into 'engineering capital' in Chinese higher education contexts. University-based engineering capital is added to the concept to recognize the influence of the university as a 'field' (Bourdieu, 1984) embedding engineering capital. Engineering faculty members and seniors/peers in the same major are argued to be engineering social capital embedded in the university field. Engineering curriculum, pedagogy, mentorships, experiments, assessments and other related infrastructure and facilities can embody university-based engineering cultural capital. It is predicted that students at more prestigious universities have more access to university-based engineering capital. Students with lower family-based engineering capital can empower themselves by taking agentic actions to acquire more university-based engineering capital, such as developing close relationships with engineering faculty members and seeking help from them. It is also essential for university teachers in engineering to be gender-sensitive and for higher education institutions to provide a more gender diverse and inclusive education environment. University provides a field that has the potential to disrupt the class reproduction present in engineering capital.

A framework of pre-university engineering social capital is established based on the Chinese contexts and considering the ‘human society’ that prevails in China. Additionally, a distinctive approach has emerged: family members working in engineering can assist with career choices by leveraging their social networks to help students find internships and jobs within the engineering field. In addition, engineering disposition/habitus is defined as ‘future engineering affinity (interest, self-efficacy and admiration to engineering and engineers)’ and ‘engineering subjectivity (the sense of whether engineering is ‘for me’, and sense of pride in being an engineering major)’. It is clearly positioned as both the results of acquiring engineering capital and exists alongside the accumulation of engineering capital. ‘Engineering-related behaviours and practices’ and pre-university cultural capital are not further illustrated in this chapter because they are similar to Archer’s original theorization. Engineering social capital is argued to be the key to influencing engineering career choices, in which process cultural capital and habitus play more crucial roles in sustaining the engineering career choices. Finally, engineering capital is argued to be gendered and male-dominated. Therefore, it is suggested to maintain a gender sensitive approach when utilizing engineering capital to empower women engineering students. The culturally sensitive nature of engineering capital is emphasized to remind researchers to consider cultural implications when applying this concept.

10.2 How are Chinese female engineering students motivated to learn engineering at university?

Both the survey and semi-structured interviews help with understanding the motivations of Chinese female students when choosing an engineering major at university. The survey asked both male and female engineering students from year one to year four at universities in Shandong province to briefly describe ‘their reasons to learn engineering at university’ and rate their level in the adapted ‘science and engineering capital index’. The interviews explored their more thorough pre-university experiences, including schooling, family involvement, the decision-making process of ‘Gaokao’ and how these were related to the decision to study engineering. This study finds that based on how the specific educational system in China is structured, gender and SES intersect to make a difference in shaping the agentic subject choices of the sample female engineering undergraduates.

10.2.1 The Chinese educational context

The thematic coding of open survey questions indicates that ‘psychological factors’ (e.g. interest and self-efficacy) and ‘discipline characteristics’ (e.g. useful discipline and career prospects) are the primary reasons for choosing engineering (see Section 6.7.1). However, female respondents cited these reasons slightly less often than male students; instead, they more mentioned reasons related to the ‘educational system’ (e.g. university admissions system), although significance testing was not performed. This suggests that female students’ choices could be more influenced by the ‘educational system’ compared to their male counterparts.

Findings from semi-structured interviews suggest that this can be a result of gender norms that prevail in Chinese society. Gendered social norms tend to shape what individuals perceive of as acceptable roles for women and men in both private and public spheres (Budgeon, 2014). It is largely accepted that the shadow of Confucianism looms over women in China, constraining their preferences and behaviours, and reinforcing the power of the patriarchy (Fang, 2021; Pang-White, 2018; Pang-White, Ram-Prasad & Tan, 2016). In the field of engineering, women are often stereotypically regarded as unsuitable and disadvantaged, due to their perceived emotional traits, weaker physical strength, greater responsibility for domestic issues and lack of talent in engineering (Barhate et al., 2021; Chakraborty & Chatterjee, 2021; Gunderson et al., 2012; Male et al., 2018; Tzu-Ling, 2019; Vidal et al., 2020). When women are not socially encouraged to study engineering, their choices surrounding engineering undergraduate programmes often feel passive, influenced by the educational system rather than a result of an interest in the engineering discipline.

The exam-oriented education model in Chinese high school has been widely criticized as undermining students' imagination, creativity and sense of self (Kirkpatrick & Zang, 2011; Liu, 2023). Some interview participants were unsure of their areas of interest, attributing this to how high school education in China places too much emphasis on students achieving high scores. Participants also expressed their lack of knowledge about undergraduate programmes when they applied for universities, particularly those from lower-SES families, who are more likely to lack the expertise to choose well-matched universities and majors (Hill & Winston, 2010; Hoxby et al., 2013). This was recently emphasized as an important issue in Chinese educational system by Li and Zhong (2023). When female students have no preference for subjects, being affected by patriarchal gender norms, they may unconsciously distance themselves from choosing an engineering major. However, several female participants (N=8) were assigned to engineering undergraduate programmes due to the 'tiaoji' system in the university admissions process. When their 'Gaokao' score, the only standard for university admission in China, is not high enough, they tend to prioritize the prestige of university over a preferred major. To ensure they can be enrolled at a reputable university, they chose to accept the outcome of 'tiaoji'. This strategic decision reflects their agentic engagement in navigating the university admissions system.

Additionally, the perception of science as superior to arts is deeply entrenched in China's educational system across all stages (Zhang, 2021). In the context of the Chinese language, 'science' here typically means STEM disciplines, while 'arts' refers to humanities and social science subjects. According to my interview participants, the suggestion to choose science subjects overwhelmingly came to them from schoolteachers, parents and relatives. Chinese scholars note that these suggestions are rooted in the perceived superiority of science and the undervaluation of the arts, and have adverse effects on Chinese education development

(Yang & Deng, 2018). This notion is in line with the idea of masculinity superiority over femininity. What is often overlooked by existing literature but argued in this study is that this embedded social discourse in Chinese education system can act as an approach to empower women in resisting gender norms. When educational resources and public opinion are predominantly directed towards science subjects, despite the prevailing gender norm suggesting that science is not for women, several female students turn to science-oriented choices. The essence of this process is using science to empower women in Chinese society, increasing opportunities to study STEM subjects and gain affluent incomes as men do after graduation in these domains. Thus, numerous studies have focused on the underrepresentation of women in STEM fields across different life stages (see Dos Santos, 2022; Fouad, Fitzpatrick & Liu, 2011; Nguyen et al., 2022; Tandrayen-Ragoobur & Gokulsing, 2021). Usually, in China, only students choosing science subjects in high school are eligible to apply for engineering programmes at university. Hence, choosing science subjects gives female students at least the chance to apply for engineering undergraduate programmes.

Overall, in the Chinese high school curriculum, there is a notable absence of components aimed at exploring personal interests and acquainting students with university programmes. The Chinese ‘Gaokao’ system is genderblind (Han et al., 2024), so it does not support students to understand the gendered structures at higher education institutions. Although the perceived superiority of science over arts reproduces the hierarchy and further devalues arts-related subjects, it could be a potential approach to empower women. The specific educational contexts in China discussed in this section can, to some extent, make the gender norms disadvantaging women in engineering less pronounced at the time of university subject choices. However, this suppressive effect seems to be temporary. When these women enter a new field (Bourdieu, 1984) – the engineering department at university – the male-dominated environment would exacerbate existing gender norms, further marginalizing female engineering students. Also, entering an engineering major without the motivation of genuine interest and willingness can be unhelpful for transitioning female engineering students into the engineering workforce.

10.2.2 Family and teachers assisting females in building dispositions in science and engineering in high school

Factors mentioned in the previous section mainly relate to how China's educational system drives some female students with lower level of engineering dispositions into engineering majors. This section brings the intersectional aspects of SES into the discussion of empowering female students to choose engineering subjects.

The survey results suggest a larger proportion of my respondents had a high level of 'science and engineering capital' compared to secondary school students in the UK (Archer et al., 2015). This might be because my respondents had already selected engineering subjects at university; this could reinforce the argument that obtaining a higher level of science capital could enhance science/engineering aspirations (ibid). Furthermore, female students (M=45.71) reported a slightly higher 'science and engineering capital' score on average than male students (M=45.01) (though not statistically significant). This does not mean women do not need more support regarding science and engineering capital, because the qualitative data indicate that engineering-related capital can empower them to cultivate interest and self-efficacy towards engineering, resisting the gendered social structures.

According to some interview participants, self-efficacy and interest in science subjects in high school tend to be among the main motivations for choosing engineering at university. This resonates with existing research that underscores the influence of maths and science attitudes and performance on students' STEM participation and aspirations (Jiang, Simpkins & Eccles, 2020; Godec et al., 2024; Godwin, Potvin, Hazari & Lock, 2016; Starr & Simpkins, 2021). In addition, this study suggests that family members and schoolteachers tend to be the major influences for female students in cultivating interest, self-efficacy and admiration in science and engineering at the pre-university level.

According to Bourdieu (1990b), agency interacts with structure through the working of habitus, and agency is allowed in the habitus system, but habitus tends to predispose individuals to a certain mode of behaviours. Habitus is a socialized body, carrying both dispositions and embodiment (Bourdieu, 1990a, 1998). Bourdieu (1990a) regards the dispositions as being produced by various opportunities and constraints among the earlier life experiences of individuals. Based on the narratives of participants in this research, engineering dispositions and/or habitus specifically refer to the interest, self-efficacy and admirations towards engineering, and engineering subjectivities (defined in Section 10.1.2.3). In addition to the participants (N=8) being pushed into engineering undergraduate programmes by the educational system in China, others (N=8) developed engineering dispositions due to their family's engineering capital, including social and cultural forms of capital. The engineering dispositions cultivated would drive students to actively choose engineering subjects, rather than being restricted by gender norms discouraging women from learning engineering. Meanwhile, because the exam-oriented teaching model in Chinese secondary education largely neglects cultivating students' engineering dispositions, engineering-related capital embedded within students' families could play a crucial role in shaping their motivations when choosing an engineering undergraduate programme.

Meanwhile, in addition to the critical role of family engineering capital, a small number of students (4 out of 24) mentioned that they had met some teachers who shaped their interest, confidence and admiration in science subjects, driving them to engineering majors. Nevertheless, it seems that the majority of participants who claimed that they had been influenced by schoolteachers were from high engineering-capital families. Existing research indicates that parental SES is positively related to the societal involvement of students (Campbell, 2008; Wanders et al., 2020). In this case, students with low SES backgrounds are further disadvantaged in the educational and social settings. Unfortunately, this study did not dig further into the relationships of how family-based engineering capital affect students' way of interactions with schoolteachers related in science and engineering. Future study is suggested to investigate this point.

Finally, I would like to summarize the answers to the second research question. Overall, the Chinese educational system is regarded as a venue where gender and SES intersect to make a difference. For Chinese female engineering student participants, prevailing gender norms seem to be less influential in their choice of university major. On the one hand, the Chinese educational system drives some female students (as well as male students, since the university admission process is gender-blind) who did not have a strong intention to learn engineering into engineering undergraduate programmes. The system includes an exam-oriented elementary education mode, the 'tiaoji' system, which is based solely on 'Gaokao' scores, emphasis on university prestige over personal interest in major, a lack of instructions on undergraduate programmes, and the general perception of science as being superior to the arts. On the other hand, some female students have more access to family-based and school-based engineering capital, which can empower them with engineering dispositions and motivate them to choose engineering majors. Therefore, considering gender, SES and the educational system in China from an intersectional perspective, female students negotiate with their past, present and future in an agentic way, choosing engineering undergraduate programmes as a response to these complicated and inter-related social structures. The female students cannot be treated as a homogenous group in university engineering study, as they have varied motivations for entering the field due to possessing different levels of pre-university engineering capital. For example, participating female students who were allocated into engineering programmes often struggled to develop sustained and long-term engineering aspirations, compared with those who had obtained higher levels of engineering capital in family and school settings. Factors related to gender, family SES, previous education and their university admissions process need to be accounted for when providing support to female engineering students at university.

10.3 What are the experiences of female engineering students at universities in China?

As I have emphasized throughout this thesis, career choices can be influenced by all stages of previous experience. One of the major purposes of exploring university experiences is also to investigate how they affect the career choices of female engineering students. The university experiences were investigated through both survey questions and semi-structured interviews, focusing on academic performance, engineering agency, images of engineers, classroom experiences and after-class engineering activity experiences. In the survey (see Chapter 6), female students, on average, tended to report higher engineering agency, better academic performance, less stereotyped views of engineers, more positive classroom experiences and less positive practical experiences than male students (though many of them were not statistically significant). It is important to note that the female respondents (46.8%) had a statistically significant weaker desire to pursue an engineering profession than male respondents (60.9%). Furthermore, previous studies (Carnemolla & Galea, 2021; Kamphorst et al., 2015; McCullough, 2019; Swart, 2018) argue that though women engineers might have positive working experiences, they can also suffer from negative views and social stigma that restrict their self-efficacy and sense-making processes. The follow-up interviews in this study provide a more thorough understanding of female engineering students' university experiences, unveiling the struggles faced by female students beneath the apparently robust statistical survey numbers. As a contribution of this study, several of the institutionalised gendered structures that shape the experiences of female engineering undergraduates were identified through interviews, including the monoglossic atmosphere shaping mixed engineering belonging and subjectivities, the gendered practical work assignment and the gendered assessments.

When it comes to the rural-urban divide, as a reflection of family SES in the survey, female students from urban backgrounds tended to report slightly higher engineering agency, more stereotyped mindsets towards being an engineer, more positive classroom experience and practical experiences than their rural counterparts (though often not statistically significant). Nevertheless, the interviews found little involvement of family influence in their stories about university experiences. Family SES often plays a vital role in the process of finding internships and jobs, which will be discussed in Section 10.4.

10.3.1 The monoglossic gender atmosphere shaping belonging and subjectivities of female engineering students as heteroglossia

According to my study, female engineering students tend to experience a mixed sense of belonging. Female survey respondents (M=3.57) on average rated a slightly higher sense of belonging than their male counterparts (M=3.53) (though not statistically significant). While this is apparently different from most existing findings emphasizing women's lack of belonging in engineering (see Derricks & Sekaquaptewa, 2021; Wilson & VanAntwerp, 2021; Tate & Line, 2005), the qualitative results indicate that their sense of belonging comes at a cost. Though female engineering students often take agentic actions to resist gender segregation, such as being psychologically prepared for possible loneliness and forcing themselves to perform in a boyish way to socialize with male classmates, they have to devote more psychological resources to mitigate the internal gender segregation that stems from engineering's male dominance. China-based research shows that mental health distress among female engineering students is positively related with the tensions in their interpersonal relationships (Wang et al., 2022). Managing hostile environments can be emotionally debilitating (Mkhize, 2022). Besides, the qualitative findings indicate that some female students (N=5) tended to treat the care and favour from male classmates as an approach to nurturing their sense of belonging. However, granting women privileges is a way for patriarchy to solidify its dominance by framing women as being loved, cared for, and disciplined in gender relations. When women accept those privileges, they are likely conforming to essentialist gender rules.

This study shows that gender essentialism and gender segregation persist in engineering undergraduate programmes at Chinese universities, hindering the social interactions of female students as a minority within the majority of male students. Many participants mentioned that 'boys play with boys and girls play with girls' in their classes at university, which originates from the Confucian precept that after the age of seven, boys and girls should not eat or sit together (Walthall, 2020). They also complained that this segregated socialization situation posed challenges in their social lives and academic learning. Similar to Jaremus's research (2021) regarding girls participating in post-compulsory mathematics as gender heteroglossia, in my research, women learning engineering at university can be regarded as a heteroglossic behaviour and attempting to across the boundaries of monoglossic gender norms. As illustrated in Chapter 2, gender monoglossia refers to the dominant binarized gender matrix and gender normativity, while gender heteroglossia describes multiple and fluid discourses related to gender (Francis, 2012). Females participating in engineering are not expected in the monoglossic gender system. To ensure the hegemonic monoglossic gender system continues to reproduce itself, it constrains and pathologizes heteroglossic disruptions to monoglossia (Butler, 1993; Francis, 2010, 2012). The social climate embedded in the male-dominated environment serves as the monoglossic gender system that can punish these female heteroglossia as claimed by Abrams and colleagues (2003) and Sauntson (2012).

Further, this study suggests that these female engineering undergraduates are 'punished' mainly because of the social connotations embodied in their female bodies, rather than their acquisition of masculinity. In the context of engineering, survival may favour female masculinity over female femininity. When females enter the field of engineering after

‘Gaokao’, crossing gender boundaries becomes their strategy to fit into the masculine field, as they find that femininity is not welcomed in engineering education and workplace settings. This reflects the students’ agentic adaptation to social structures. As illustrated in Chapter 8, most female engineering participants align themselves closely with either a masculine gender subjectivity or a gender-neutral one. From their narratives, some were raised with masculine values by their parents, but most acquired or strengthened masculinity as they became more deeply involved in engineering majors. Williams (1989) argues that women and men in non-traditional domains, such as female marines and male nurses, tend to actively construct their gender subjectivities by redefining their roles based on traditional feminine and masculine traits (gendered habitus). Women in such a situation tend to minimize the differences in roles between themselves and their male counterparts (ibid).

Also, the Chinese female engineering students participating in my study tended to show monoglossic and essentialist views on gender characteristics among men and women out of biological determinism. Chinese women were described by participants as more patient, responsible, meticulous, diligent, skilled in communication, emotional, obedient, considerate and timid. Chinese men were regarded as more confident, braver, with better spatial imagination, divergent thinking and logical thinking ability, more proficient in hands-on tasks and skilled in technological outputs. The attributes associated with engineering and engineers are commonly regarded as masculine. Hence, it seems that for females, doing engineering means performing masculinity. This study argues that females doing engineering have the potential to disrupt what Butler calls the ‘heterosexual matrix’ (1990, 1993), although these females tend not to subvert the monoglossic gender system. Francis (2012) claims that within broader social and cultural practices, potentially disruptive and heteroglossic elements exist without challenging the entirety of the monoglossic façade. Therefore, I argue that to resist the power of gender monoglossia, female engineering students need to be empowered from the outside, such as through capital-related and institutionalised factors, which will be discussed in the upcoming sections.

While the male-dominated climate leads female students to feel marginalized, it is worth noting that a sense of pride emerged from most female engineering participants' descriptions of their engineering subjectivities. The sense of pride seems to be rarely explored in relation to engineering participation within existing literature. I found only one study, conducted in the US as early as 1998, which suggested that a sense of pride is strongly associated with choices of major in STEM fields by women and minorities in STEM subjects (Leslie, McClure & Oaxaca, 1998). The female participants in my study felt superior and proud to be engineering students who had acquired scientific and technological logic during learning, compared to students learning humanities and social science subjects. They tend to reproduce the binary construction of science as superior to arts and humanities. This is linked to the binary construction of men and women, as men are socially perceived as being more suitable for science subjects, whereas women are regarded as more suitable for art subjects (Diekman et al., 2010). Considering their pathway to engineering majors, the perception of science as superior to arts acted as an empowerment for them to access engineering (Section 10.2.1), and when it comes to university, this sense of superiority persists. Nevertheless, the positive engineering subjectivities among female students are not present in their peers learning art and humanity subjects, especially women, rather than male classmates in engineering. Therefore, the engineering subjectivities of these female students is argued to be contextualized and situational. Though the perception of science as being superior to arts can empower women to access engineering, it may not assist them in disrupting the monoglossic gender atmosphere of engineering.

William's (1989) famous work on female marines and male nurses indicates that an increase in women and men in non-traditional occupations does not necessarily lead to a decrease in gender segregation as they still tend to perform their gendered roles under the influence of traditional social gender norms. Therefore, the gendered definitions of certain domains have not been challenged. However, in my view, this is a conclusion that only considers the perspective of gender. The monoglossic gender atmosphere in engineering can constrain the belonging of female students, but when considered in intersectionality with SES, female students can be empowered by engineering capital to disrupt gendered monoglossic roles in the engineering domain. Section 10.4 elaborates on this mechanism.

The final point I want to address regarding female students' sense of belonging in engineering is a contradiction observed in participants' narratives. On the one hand, some participants held robust modern feminist mindsets and believed that females as a whole can undertake tasks equivalent to males. That can be a possible reason why female respondents on average rated lower scores in agreement with the stereotyped items in the survey (though many items were not statistically significant) which described the general population. On the other hand, they often ascribed their decision to leave engineering after graduation under the influence of gender norms as a personal choice, emphasizing that it cannot represent all women as a group. This observed phenomenon is similar to the findings of Powell, Dainty and Bagilhole (2012), who suggest that female science and engineering students in the UK often hold contradictory subjective views; possessing gendered stereotypes about women's unsuitability for traditionally masculine jobs yet also believing that all people can pursue science and engineering if they wish to. A possible explanation for this contradiction observed among Chinese female engineering students could be that during the social transition period in China, under the mixed influence of modern feminism emphasizing female power (Liao, 2020; Mao, 2020) and traditional monoglossic gender norms disadvantaging women in engineering, female engineering students tend to experience mixed subjectivities regarding gender and engineering. They are contradictory entities, absorbing various social impacts in making their final decisions about careers inside or outside engineering.

10.3.2 Gendered practical tasks

'It's tiring and dirty, let him do it' (Zheng, outside engineering) – this seems to be an ingrained idea and unconscious gesture adopted by female students, male students and university faculty alike, as evidenced by the insights shared by interview participants. Women's perceived smaller bodies and weaker physical strength are regarded as 'perfect' excuses for marginalizing female students in many practical and physically demanding tasks in engineering fieldwork, such as equipment installation, pipeline maintenance and scaffolding climbing on construction sites. Women have been kept out of engineering not because they are incapable, but because men and those in decision-making positions believe they are. In a patriarchal society where men hold most positions of power, their definition of gender tends to be the one that is institutionalized in practice (Mensah, 2023). Under the influence of patriarchal gender stereotypes, even women can sometimes believe they are incapable. Building on William's (1989) argument that the gendered labour division reflects men's reluctance to regard women as equals, I argue that the sex segregation in Chinese engineering higher education reflects not only men's inability to treat women as equals, but also women's inability to see themselves as equals. Empowering women tends to be important under this circumstance.

Both the survey and interviews revealed that female engineering students tend to have fewer opportunities to do hands-on tasks and take part in practice-oriented competitions in engineering. Some interview participants, when reflexively diagnosing the situation, were aware that the 'care' and 'favouritism' provided by faculty and male students could be a veiled deprivation of practical opportunities for them. This practice can exaggerate gender segregation in the field (Martin, Fabes & Hanish, 2014). In this scenario, female engineering students can be positioned into 'token' roles (Kanter, 1997) in a male-dominated environment (Quadlin, 2020). Although male students typically shoulder primary responsibilities for these apparently exhausting tasks, when investigating deeper, the learning environments created are still biased in favour of male students at the expense of their female counterparts, as defined by Balakrishnan and Low (2016). Perrenoud and colleagues (2020) found that women in the electrical construction industry in the US often have fewer promotion opportunities on account of their lower levels of craft training. More importantly, some female participants in my study developed a genuine interest in engineering after engaging in experiments, which motivated them to pursue further studies and careers in the field. Lack of practical opportunities hence might hinder women from fully cultivating their interest in engineering.

Engineering is a discipline that requires high practical capabilities, in which case the gentlemen culture within engineering higher education is argued by this study to hinder the progress and retention of female students. The ‘gentlemen’ culture, which prioritizes women in trivial matters, represents a growing discourse on gender/masculinity in Chinese society, evolving from past attitudes of contempt toward women (Cao, 2021). However, the accommodation of male engineering students is largely influenced by the tendency of men to hold more negative stereotypes towards women’s ‘low’ engineering capabilities (Jones, Ruff & Paretti, 2013). It will not contribute to cultivating female students’ independence, passion and competence in engineering study. Instead, they might be marginalized due to being kept away from the so-called heavy and dirty tasks that are required in engineering learning and practice. It is also observed that men tend to show care to women in ways that do not ‘threat’ their benefits in engineering, while in the case of real benefits, they tend to strive for men as a group, such as when voting for prestigious awards or evaluating students in financial need as exampled by interview participants. When men hold the central/majority of the power, more men enjoy the bonuses brought about by their gender. The patriarchal nature is evident in this phenomenon where patriarchy only grants women privileges in aspects that can reinforce their roles of being disciplined in gender relations.

In the process of gendered assignment of practical tasks, university teachers act as authoritative proxy agent instructing their students to perform their gender; male students perform their 'gentlemen script of masculinity' provided by not only university teachers but also social norms embedded in their daily routines, while female students enjoy the so-called 'privileges' associated with their femininity. In this process, all three subjects (female students, male students, university teachers) have exercise their agency to perform their gender, yet their agency and performance are constrained by repetitive and stylized social behaviours and language (Butler, 1990, 1993). Although these female students enter engineering programmes at university as heteroglossia, their experiences are largely shaped by the powerful and ubiquitous monoglossic gender binary. However, from an intersectional perspective, a lower SES family background may help female students disrupt the stereotypical mindset and gendered habitus that girls should not do 'dirty' work; Peng mentioned that growing up in rural areas accustomed her to dealing with such tasks. Besides this, I note that in this process, university teachers play a coordinating role with an authority who expects male and female students to perform their masculinity and femininity respectively. Their practice can be argued to be affected by normative heterosexuality (Butler, 1990, 2004). They can be important figures in university-based engineering social capital in empowering female engineering students at university with disruptive and heteroglossic elements. Therefore, this study emphasizes the need to provide targeted training to engineering faculty members to be more gender-sensitive to allow fluid gender subjectivities of students and to provide equal practical opportunities to both male and female engineering students.

In addressing the third research question about the university experiences of female engineering students, it is also important to note that the institutionalized culture of gender includes frequent discouragement from faculty, particularly male faculty members (Morris & Daniel, 2008). When engineering students' competency and work is questioned by professors, students' self-efficacy can be undermined (Riney & Froeschle, 2011). It is thus necessary to build a faculty team of gender-sensitive lecturers who are aware of gender dynamics in their teaching practices and create an inclusive learning environment. Meanwhile, it seems that female faculty members are more likely to assist female students by offering them additional opportunities and support, which is essential for the retention of female STEM students (Chesler & Chesler, 2002; Dasgupta, Hunsinger & Scircle, 2014; Stillmaker et al., 2020; Stout et al., 2011). Men who benefit from gender privilege in a patriarchal society often cannot fully understand the obstacles and dilemmas faced by women (Kimmel, 2018). Stillmaker and colleagues (2020) highlight that female engineering students have a significantly greater need for mentors and professors of the same gender compared to male and non-binary students. It is thus important to emphasize both faculty quality and diversity in engineering programmes (Leach, 2010).

10.3.3 Gendered assessments

While most of the existing literature focuses on the gendered environment in engineering and STEM majors generated by the dominance of male students and faculty (see Bennett, Bawa & Ananthram, 2021; Bloodhart et al., 2020; Sax et al., 2016; Shafiq et al., 2024; Sonnert, Fox & Adkins, 2007), problems in relation to assessments have been largely neglected. This study finds a new approach to gendered assessments to interpret how female engineering students tend to have lower self-efficacy even when they achieve higher scores in engineering exams at university.

Similar to existing global studies that highlight women's high academic performance in engineering and STEM majors (see Bloodhart et al., 2020; Buchmann & DiPrete, 2006; Kamphorst et al., 2015; Liu, Shen & Li, 2021), this mixed-methods research confirms that female engineering students tend to outperform their male counterparts in examinations at university, but they tend to experience lower STEM self-efficacy (Ireland et al., 2018) and lower competency confidence in undertaking professional engineering roles (Craps, 2022). This challenges the common assumption that students' perceptions of self-efficacy are important predictors of academic achievements in engineering programmes (Vogt, Hocevar & Hagedorn, 2007). This situation is defined as 'academic impostorism' by London and Dweck (2005) to describe the self-doubt of academic inability, fear of failing to reproduce past successes, and concern about being discovered as lacking competence. Feelings of impostorism can have both social and academic implications that are negatively associated with individuals' sense of belonging and self-efficacy, both of which are associated with a negative inclination towards considering dropping out of STEM programmes (Clark et al., 2021; Tao & Gloria, 2019). Hartman and Hartman (2006) claim that unfavourable socio-cultural experiences often erode the self-efficacy of even the most capable female engineering students at university. The United Nations (2010) provides a potential explanation for why women in traditional men's domains underrate their success. It is suggested that women are influenced by the dominant culture within those domains and tend to 'perceive any discrimination they encounter as a result of their own shortcomings' (United Nations, 2010: 113). A study by Torres-Guijarro and Bengoechea (2017) further reveals that female engineering undergraduate students tend to be too harsh in their self-assessment, leading to lower self-efficacy.

Considering the contexts of China, this study argues that in addition to the internalised self-perception from a socio-psychological lens of self-efficacy, the social structures of institutional assessment approaches produce a gendered space where female students' agency is suppressed and their confidence is impacted. Based on the qualitative findings, two approaches regarding gendered assessments were identified: 1) different assessment standards for female and male students in hands-on activities; and 2) assessments that focus too much on written content.

The first approach is associated with the gendered assignment of practical tasks discussed in the previous section. Lower assessment standards for female students cannot help improve their engineering competency and skills, particularly skills valued in the engineering workplace. Meanwhile, their self-efficacy is unlikely to be enhanced when they realize that their performance is assessed differently from that of male students, such as being given longer time to complete a task. Faculty and peers in STEM programmes tend to attach great value to innate talent, while women are stereotyped as being less talented in these fields. Together with women's perceived weaker physical strength, lower assessment standards toward females tend to be regarded as a form of special care for them. Consequently, even when women have achieved something in these fields, they doubt their ability, discount their past achievement and question their potential for success in the future (Clark et al., 2016).

The second assessment approach is identified as gendered because it further reinforces the stereotype that women are good at memorizing, while men are good at comprehending. Existing indigenous research on the 'boys' crisis' in China tends to view girls as better at dealing with paper exams, which are the major (or in most cases, only) form of assessment in Chinese compulsory education, leading to lower academic performance among boys during this stage (Li & Yan, 2021; Li & Zhang, 2018). But when it comes to higher education contexts in China, the same situation seems to disadvantage female students. At university, scores are no longer widely accepted by students as a representation of ability and competency, because there are more diversified activities at university than pre-university's score-centred educational model. Six female interview participants ascribed their high scores to rigid memorization of textbooks. To achieve higher scores in exams, when they had difficulty understanding certain content and knowledge, they often resorted to rigidly memorizing the textbooks and knowledge. Many interview participants (19 out of 24) complained about how difficult engineering is for them, and how easy for their male classmates as they saw it. This is in line with the quantitative results that female respondents (M=3.54) rated their engineering workload as too high compared to their male counterparts (M=3.48).

Therefore, high grades achieved under the current assessment system do not foster a sense of achievement and self-efficacy, but rather feelings of frustration and powerlessness. An assessment system that emphasizes written answers may unintentionally reinforce women's tendencies to pay more attention to memorizing textbooks rather than trying to understand the engineering knowledge and applying it in practice. As most students at higher education institutions pay more attention to improving their assessment performance than to other aspects (Cilliers et al., 2010; Kickert et al., 2022), it is important to enact more practice-oriented assessments to give students more and equal opportunities to practice their engineering vocational skills and enhance their self-efficacy as females in engineering. It would also be a way for universities to foster more university-based engineering cultural capital.

At the end of this section, I summarize the answers to the third research question. Within the structures of monoglossic gender atmosphere, gendered practical tasks and gendered assessments in engineering programmes at university, gender becomes a 'regime' of truth that conditions how female students perceive themselves in engineering. A mixed sense of belonging is identified among female engineering students. This is manifested through gender segregated socialization and the apparently robust sense of belonging coming at the cost of increased psychological devotion. Female students participating in engineering are analysed as gender heteroglossia being constrained by the monoglossic gender system in engineering higher education institutions. They tend to perform in alignment with traditional masculine traits expected in Chinese engineering work, to better fit into the engineering environment. Despite being largely marginalized by the male-dominated engineering environment, they take pride in learning engineering. This continues the perception they acquired from school that science is superior to the arts. However, this subjectivity is situational and relational, as it diminishes when compared with male peers learning engineering. Therefore, female engineering students would not be able to subvert the gender monoglossia in engineering programmes without external assistance.

In addition, female engineering students at Chinese universities experience another two institutionalised gendered structures – gendered assignment of practical tasks and gendered assessment – that can hinder their self-efficacy and interest in engineering. Female students have fewer opportunities to engage in practical tasks, especially those regarded as dirty and tiring, although these tasks can provide important opportunities to strengthen their disciplinary knowledge and engineering skills. And they sometimes 'enjoy' lower assessment standards for practical hands-on activities, which seems to offer no real benefits to female students apart from making their scores look good. Besides, the assessments over-emphasize scores in paper exams, pushing many female students to rigidly memorize knowledge from textbooks, reproducing the stereotype of women being good at memorisation but lacking logical thinking skills. These problematic practices in engineering higher education institutions not only reflect how patriarchal gender norms impact individuals and institutions but also provide some possible solutions regarding faculty development and assessment schemes to empower female students in resisting the gender monoglossia in engineering programmes and increasing their aspirations for engineering careers.

10.4 How do gender and SES intersect to shape the career choices to continue in or leave engineering of new Chinese female engineering graduates?

As illustrated in Chapter 4, inspired by the Social Cognitive Career Theory (Lent, Brown & Hackett, 1994), this research combines contextual influences and agency in exploring the career choices of female engineering newly graduates. Gender norms and SES discourses are identified as influential social structures shaping how students exercise their agency to navigate these contextual influences. I regard career decision-making as an ever-evolving process (Smith & Gayles, 2017), with choices being made through the process of the long-term interactions between structure and agency. This research finds that traditional monoglossic gender norms and institutionalized culture pose various difficulties and challenges to female students in engineering, while pre-university and university-based engineering capital can empower them to agentically resist unfavourable social constructions and opt for a more sustainable career in engineering. More attention thus is suggested to be paid to enhancing engineering capital in different settings.

10.4.1 Synthesizing gendered mechanisms in different settings that hinder career choices in engineering

The survey results confirm the dominant conclusion in existing research that smaller proportions of women graduating in engineering enter the engineering workplace than men (Jan & Sean, 2012; Hunt, 2016; Mann & DiPrete, 2013). In previous sections of this chapter, I elaborated on how female students are constrained by prevailing gender norms in pre-university and university stages. From a young age, many girls are neglected in cultivating connections and interests in engineering (Beede et al., 2011; Meadows, 2016). They may internalize negative stereotypes from an early age and begin to believe them (Walton, Spencer & Erman, 2013). While some enter engineering programmes at university primarily due to the specific impact of the Chinese educational system, without a genuine interest and motivation in learning engineering, they are at a disadvantage from the outset. In the new ‘field’ (Bourdieu, 1984) of the university, the male-dominated environment tends to erode female students’ sense of belonging due to the existing monoglossic gender segregation. The gendered practical tasks and gender assessments they experience can further undermine their self-efficacy and interest in engineering. In this case, when these female students exercise their reflexive agency to analyse their surroundings and listen to their inner conversation, they are more likely to distance themselves from engineering careers.

When it comes to a scenario that is more closely associated with career choices, the gender discrimination in the engineering job market becomes a common concern for all interviewees.

Participant observed discriminatory practices in the engineering job market include the implicit and explicit preference of males during recruitment (Amani et al., 2021), more stringent requirements for female jobseekers (Xu & Yu, 2013), different job assignments based on gender or their perceived abilities associated with gender and huge difficulties in promotion for women (Wynn & Correll, 2017; Baruah & Biskupski-Mujanovic, 2021). Most participants felt powerless to resist such discrimination as they were unable to change the requirements of employers. Only those with engineers in their families found it easier to secure a job with the assistance of their social networks.

The reasons for this discrimination can be traced to entrenched gender norms in Chinese society, including gendered labour divisions, issues related to pregnancy, and perceived physical weaknesses. Because of these gender norms, traditional parents also tend to discourage their daughters from pursuing a demanding engineering career. It is noteworthy that, resonating with the findings of research regarding work-life conflict (Williams, 2018), mothers and prospective mothers tend to blame themselves for the intense work-family conflict they experience and many female participants tended to profess understanding of the biased practices of employers. There can be two possible reasons: 1) Confucian education of females in China reinforces their traits of being understandable and unselfish; and 2) they exercise their agency to conform to the gender norm that suggests pursuing a stable and less demanding job is more suitable for women, which is also a common parental expectation for their daughter's future career. This reflects how powerfully the social structures affect individual agency (Meyer & Jepperson, 2000).

Before entering the job market, students can experience an engineering working environment through internships. Both the survey and interview findings confirmed that it is difficult for female engineering students to find an internship as male-preference still exists (Baruah & Biskupski-Mujanovic, 2021; Wen et al., 2023). However, engineering-related social capital embedded in their family background can provide female students with concrete assistance in securing a desirable internship position (Martin, Gipson & Miller, 2011). Among the 24 interview participants, only seven had engineering-related internship experiences. This further verifies the deficiency in terms of practical experiences among female engineering students.

Moreover, some participants (N=5) doubted whether they could adapt to the engineering working culture after internship (Seron et al., 2016). These female students had traditional gendered mindsets, subconsciously rejecting work environments and tasks that do not align with traditional feminine traits. Contrarily, a smaller number of participants (N=2) spoke positively about their internship experiences and felt excited because they offered them valuable insights to inform their future plans within engineering. These two participants both possessed relatively high levels of family engineering capital, supporting them in cultivating a strong interest in engineering and anti-stereotypical mindsets. From securing an internship position to cultivating engineering dispositions, family engineering capital can compensate for some of the disadvantages faced by female students. Students' previous experiences and perceptions influence how they approach and interpret their internship experiences. Internships can provide female students with both the challenges and joys of working in engineering (Brush, 2013) – some students pay more attention to the difficulties, while others focus on the benefits and joys. Therefore, internships tend to serve as an augmentation of previous assumptions and understandings about engineering and engineers. This further highlights the significance of creating a more inclusive and gender-sensitive environment in not merely the workplace but also higher education institutions. Once these issues are addressed, internship experiences can become more positive and serve as a means not only to encourage female engineering students but also to equip them with the practical experiences necessary to become successful engineers.

Although female engineering students face various challenges that might discourage their engineering career aspirations, many still choose to pursue a career inside engineering.

Some pursue a master's degree to empower themselves with academic qualifications – a common strategy among undergraduate students in China, particularly during the era of 'education inflation' (Liu, 2018). Some female students receive greater support and opportunities from the engineering capital they have obtained, which is argued to be essential in empowering them to work inside engineering.

10.4.2 University and family: empowering female engineering students

As discussed in section 10.2.2, family and schoolteachers play important roles in motivating female students to choose an engineering undergraduate programme. This can also shed light on their career choices. Nevertheless, when it comes to the 'field' (Bourdieu, 1984) of the university, they tend to have more limited influences, especially schoolteachers, whose impacts tend to result in lasting but subtle effects on students' interest and ability in maths, science and engineering. Due to the physical distance between university and their family home, university students experience reduced interactions with family members. Higher education can diminish the influence of family background by providing a broader educational space for students to exercise their agency and take freer actions (Zhou, 2016). Furthermore, students from rural backgrounds tend to receive much less support from their families due to limited social and cultural capital. This resonates with the argument that family-based 'strong ties' will gradually weaken for university students from rural backgrounds, while 'weak ties' formed outside the family can provide them with significant interaction advantages (Granovetter, 1983; Zhu & Cao, 2022).

This research identifies two positive influences from family on female engineering students during the university and career choice stages: 1) family members working in engineering acting as role models, motivating female students to overcome difficulties and pursue a career in this traditionally gendered discipline; and 2) family members working in engineering leveraging their social networks to help them find internships and jobs inside engineering.

The first impact has been largely evidenced to enhance girls' engineering aspirations (see Jacobs, Ahmad & Sax, 2017; Mannon & Schreuders, 2007; Thevenin & Elliott, 2015) and argued to improve their expectations of success in STEM domains (González-Pérez, Mateos de Cabo & Sáinz, 2020); while the second point seems to be less highlighted in existing literature, especially among Western research. As mentioned in Section 10.1.2.2, the 'human society' in Chinese contexts enables a novel approach by which family-based social capital takes effect. By means of social networks, some female students can be empowered to resist the gender discrimination in the job market and secure a job within engineering. Nevertheless, it is acknowledged that this mechanism may not necessarily foster ambitions for these women to work as engineers (see Section 10.4.3).

In addition to the influences of family members – discussed in Section 10.1.2.1 in relation to the reconceptualization of 'engineering capital' for the engineering domain in the context of Chinese higher education – this study finds that developing university-based engineering capital can compensate for the lack of family-based engineering capital in guiding female students to a career in engineering. They can develop engineering capital from university settings, such as by networking with faculty, peers and seniors from the same major. These significant others at university have been shown to enhance engineering the interest, aspirations and retention of female engineering students (Amelink & Creamer, 2010; Dennehy & Dasgupta, 2017), thereby strengthening their agency to resist male-dominated structures. However, it is noted in this study that interactions with female significant others tend to have more positive influences because the latter can better understand the situations of female engineering students (Jin, inside engineering). Male significant others are more likely to reproduce gender norms with female engineering students, as it is often difficult for them to fully comprehend the difficulties experienced by females living in a patriarchal society (Kimmel, 2018).

Identifying university-based engineering capital means that there are chances for female students and students from low-SES backgrounds to exercise agency to go beyond the limitations imposed by a lack of family-based engineering capital. Meanwhile, family and university have the potential to complement and enhance each other in the accumulation of engineering capital. Also, future studies could further explore if family-based engineering social capital is associated with how engineering students develop and make use of university-based engineering capital. Participating in engineering learning and practices at university can be a form of accumulating university-based engineering cultural capital, and networking with classmates and seniors from the same major as well as engineering faculty members can be a form of developing university-based engineering social capital.

10.4.3 Lacking expectations to be an excellent engineer

Women's career development in engineering can be challenging and complicated by the persistent obstacles imposed by gendered social structures (Hatmaker, 2012; Khilji & Pumroy, 2019; O'Neil & Bilimoria, 2005; Sharp et al., 2012). This research finds that the participating new female graduates who find a job in an engineering position tend to be submissive and passive towards their career development in engineering – the field fails to encourage female students to excel. Their decisions to pursue an engineering career tend to be agentic choices to secure a livelihood, often at the expense of their personal interest and passions. While they can be diligent and even committed to their work, they may not be ambitious in the field of engineering. Existing research focusing on attracting and retaining more females into engineering organizations tends to investigate factors such as career commitment (Singh et al., 2018), passionate work interest (Michie & Nelson, 2006), promotion opportunities (Hunt, 2016), masculine culture (Barnard et al., 2010; Francis & Michielsens, 2021), stereotype threat (Block et al., 2011; Bryce et al., 2019; Rosa et al., 2017) and work-family balance (Singh et al., 2018). Expectations to be excellent engineers appears to be largely undervalued in existing literature. Carthy and colleagues (2021) suggest that female engineering students show a lower preference for operational excellence than their male counterparts at TU Dublin, Ireland. The findings presented in this section highlight the importance of ensuring the field of engineering is more supportive to boost the career expectations of female engineers, forming a possible approach to promoting their persistence in engineering careers.

It is argued that engineering capital can possibly empower women to proactively navigate their engineering careers, as with this SES advantage females can develop higher interest and passion in engineering. Personal, academic, and career interests in engineering have been evidenced to drive career decision-making (Dos Santos, 2021). Obtaining a master's degree is found by this study to be a strategy for some female students (N=8), who usually have a high level of engineering capital, to enhance their career competency in engineering.

Contrary to this positive choice of an engineering master programme, a degree-driven model of pursuing a MSc in engineering has also been identified. Several female students (N=7) chose engineering master's programmes due as a result of 'education inflation' (Liu, 2018; Peng, Lin & Lin, 2022), in the belief that the alignment of undergraduate and postgraduate fields of study would improve their chances of gaining admission to a master's programme. This can be interpreted as agentic conformity to the education and job market structures in China. In this case, even though they chose further study in engineering, many intended to pursue a career outside engineering.

In summary, to answer the fourth research question, it is necessary to consider the foundational insights derived from the previous three research questions, as STEM trajectories and habitus can be formed in the overall process from early socialization (Bourdieu,1977; Master et al., 2015; Wang & Degol, 2013). Before the beginning of female student's university lives, on the one hand, some (usually those with low levels of engineering capital), with gendered habitus, were more susceptible to gender norms that distance females from pursuing engineering, entering this field mainly because of the

Chinese educational system, especially the ‘tiaoji’ policy. On the other hand, some (usually those with high levels of engineering capital) received more support from family and schoolteachers in cultivating engineering dispositions, so they tended to be motivated to learn engineering because of the appeal of the discipline. The monoglossic environment at university, the perceived gender discrimination in the engineering job market and parental discouragement from pursuing a demanding career often discourages female students as gender heteroglossia, leading to a diminished sense of belonging, self-efficacy, interest and aspirations in engineering.

However, the engineering-related cultural capital and social capital embedded within university can empower female students with both spiritual and concrete support. Besides this, family-based social capital can also provide instrumental assistance in directly securing an internship or a full-time job in engineering professional and technical positions. Internships are argued to act as an augmentation of previous assumptions and dispositions related to engineering and engineers. Engineering capital embedded in family and university settings can compensate for each other in empowering female students to agentically disrupt the gendered social structures and choose a career inside engineering. Furthermore, as the after-story of the career choices unfold, this study found that participating new female engineering graduates who had already worked as an engineer tended to exhibit a lack of ambition in their engineering careers, which can possibly result in the poor attrition of women engineers. Engineering capital can assist women in navigating more ambitious careers. Finally, intersecting gender and SES with the ‘education inflation’ that prevails in Chinese education, a number of female students chose master’s programmes in engineering with the intention of leaving this area after graduation. Future research could explore the experiences of female engineering students pursuing their master’s degrees.

10.5 Practical implications

This research has potential implications for pedagogy and teacher training in high schools and engineering undergraduate programmes in higher education institutions in China, as well as for the practices of engineering companies and organizations. There are ideological, practical, and structural changes that those institutions can implement to make engineering more accessible and inclusive for women.

10.5.1 Integrating engineering elements and guidance on university subject choices into high school education

Developing components aimed at cultivating students' interests into the Chinese high school curriculum has drawn the attention of educators and policymakers since 1994 when 'quality-oriented education' (striving for the holistic development of students) was initiated, and has been continually updated in subsequent years (Liu, 2014). However, it seems that under the pressure of 'Gaokao', high school education in Shandong province still needs to focus on improving students' scores. As noted in this chapter, the exam-oriented mode of high school education cannot be changed unless the university admission rules are reformed to a more diverse and multilevel standard. A positive national development is that specific actions have been initiated by the Ministry of Education. In 2020, the Pilot Reform of College Enrolment in Basic Disciplines (STEM fields and talent-short fields of humanities and social sciences), also known as the Strengthening Basic Disciplines Plan (SBDP), was established (Zhao, 2023). Recruitment is based on not only the 'Gaokao' score, but also comprehensive assessment results and overall quality evaluation by higher education institutions, though the 'Gaokao' score is scheduled to account for at least 85% of the final score (ibid).

As a suggested complement to SBDP and 'quality-oriented education', this research urges high school educators to take specific action to cultivate students' engineering-related strengths. Female students and those from families with lower levels of engineering capital could then enjoy more chances to be exposed in engineering, before it becomes a consideration for their university subject choices. China can learn from various Western projects that offer pupils positive STEM activities and experiences, such as the Australian project MindSET-do (McMaster et al., 2023), Canada's Let's Talk Science (Petrina, 2022), and Finland's LUMA-SUOMI (Boğar & Lavonen, 2022). A collaboration between different sectors in engineering are recommended. It is advisable for universities, businesses and museums to support high schools in providing students, regardless of gender and family backgrounds, with more opportunities to experience engineering experiments and activities while cultivating competencies through both intra-class and extra-class curricula.

Additionally, this research reveals a severe deficiency in students' knowledge of how to select university undergraduate programmes and what these programmes entail in terms of learning content and future careers. The exam-oriented education in high school places immense pressure on students – participant Ren (outside engineering) mentioned that after the 'Gaokao,' she just wanted to liberate herself from the exhausting three years of high school life struggle to achieve a high score, so she did not care much about what she would learn at university. In this case, some students may not take their subject choices seriously and struggle to make informed decisions. Therefore, it is suggested that high schools provide courses to introduce various university undergraduate programmes to students from as early as the first year of high school. In this way, students could make a more informed choice about what subjects to learn in the second year of high school, and their future university studies. Teachers should emphasize the significance of subject choice to their students, aiming to convert students' indifferent attitudes towards making subject choices.

Finally, schools and teachers are encouraged to be aware of and respond to the gender norms that prevail in Chinese social and educational settings. All the suggested practices should be gender sensitive, being fair and equal for all genders. It is thus essential for schools to provide teacher training to raise awareness about gender inequalities and promote a more inclusive environment for female students to engage in engineering.

10.5.2 Gender-sensitive higher education environment

In Section 8.4, I presented suggestions from participants' semi-structured interviews about how to create more inclusive engineering undergraduate programmes to better support female students. In this section, I combine those suggestions with the theoretical findings of this research regarding university-based engineering capital, providing practical implications for curriculum, pedagogy, assessment and teacher training in Chinese engineering higher education contexts.

As mentioned in the previous section, engineering capital is conceptualized as gendered. It originates with gendered engineering social capital, which largely provides gendered engineering cultural capital. First, I describe how universities can provide female students more university-based engineering social capital. Universities could recruit more female engineering faculty members, through for example distributing advertisements in locations that specifically attract women (Glass & Minnotte, 2010) and seeking specific funding from the government (Casad et al., 2021). Both male and female faculty members require targeted training on how to be gender-sensitive and to be aware of gender dynamics in their teaching practices so that they can work on creating a more equal, diverse and inclusive learning environment. A more gender-balanced and gender-sensitive faculty team, as university-based engineering social capital, could empower female engineering students in the so-called 'chilly climate' and enhance their engineering career aspirations and choices. In addition to faculty, as recommended by participants and existing research (González-Pérez, Mateos de Cabo & Sáinz, 2020; Milgram, 2011), inviting more successful female engineers as role models to deliver speeches and talk about their own experiences could offer valuable insights and inspiration to female engineering students.

Second, when it comes to university-based engineering cultural capital, it is essential for university faculty to provide female students with equal opportunities to participate in hands-on engineering activities both during and after class. Existing research also suggests that extracurricular involvement and research participation are positively associated with STEM career interests for female STEM students (Eagan et al., 2013; Ro, 2011; Russell et al., 2007). As participant Jin (inside engineering) mentioned, doing engineering experiments made her feel that 'it was not as tedious as what was portrayed in textbooks' and she found 'a lot of enjoyment in conducting experiments to see various results'. It is thus suggested that faculty trust female students more and encourage them to participate in engineering practical tasks, activities, and competitions, rather than granting them so-called privileges.

While allowing them equal chances for practical participation, it is also advisable to adhere to the same assessment standards for female and male students in practical activities. Otherwise, the self-efficacy of female engineering students will not be enhanced, even if they achieve high scores through considerable effort. Another suggestion in terms of assessment is to implement more practice-oriented and diverse assessments, instead of relying primarily on paper examinations. This could encourage students to practice their engineering vocational skills, rather than rigidly memorizing textbooks and formulae.

To better address the challenges faced by female engineering students in developing a robust sense of belonging, it is recommended that psychological counselling services are offered tailored to their unique challenges and needs. It would also be helpful to establish societies or clubs on campus as a living and learning community that gathers female engineering students together to foster mutual support and networking (Samuelson et al., 2014). These communities could organize regular activities to promote gender equality in engineering, such as protesting companies that exclusively recruit males from entering campus for recruitment.

As this research found that the gender monoglossic atmosphere can harm the sense of belonging and engineering dispositions of female engineering students as gender heteroglossia, it is essential to build a gender-sensitive environment in engineering higher education contexts as university-based engineering social and cultural capital to empower female engineering students to resist disadvantaging gender norms.

10.5.3 Ensuring women's needs are visible in the engineering hiring process and workplace

Gender discrimination towards female applicants continues in the hiring process in the Chinese job market, especially in STEM domains (Zhang et al., 2021). All 24 participants emphasized this issue during their interviews. When being female is seen as a disadvantage, their capability may be overlooked. As illustrated in Chapter 9, the so-called concerns associated with women's bodies, such as physical strength and menstruation, are neither natural nor unsolvable. The capitalist economic systems in patriarchal societies tend not to prioritize the addressing of women's needs. In addition to the hiring process, the work environment can be more challenging for females than their male counterparts, especially in those related to on-site work (Infante-Perea, Navarro-Astor & Román-Onsalo, 2021). Moreover, these forms of discrimination can loom over students from the very beginning of their university life, undermining their career aspirations in engineering. Therefore, changes regarding the workplace are recommended to become more inclusive and accessible to women. For example, engineering employers are encouraged to instigate ideological change to give female applicants equal chances to compete with male applicants. Considering women's menstruation, restroom accessibility and the provision of menstrual products for women during on-site work is also important. Preparing the workplace to be ready for female engineers could attract more female students to pursue a career in the engineering domain.

10.6 Limitations and future research suggestions

By employing a sequential explanatory mixed-methods approach, this research investigated the experiences and career choices of female engineering undergraduate students in China. As this study was primarily dominated by qualitative considerations, its findings cannot be generalized to the broader population. It is also acknowledged that Shandong province does not fully represent the wider country, so future research is recommended to cover more varied geographic areas in China. Limitations regarding the methodological design of this research and the self-reflexivity of the researcher were introduced in Chapter 5. This section discusses limitations of the research derived from the findings and discussions and provides suggestions for future research.

This research upholds the fluidity of gender, and the qualitative findings also show participants' potential to disrupt the binary division of men and women. However, the quantitative finding is presented by focusing on a 'women-men' binary categorization of gender, while non-binary gender identities are not considered. This is because only a small number of respondents (5 out of 532) those 'other' as their self-identified gender, which makes it difficult to engage with this data quantitatively. And I did not further ask for their exact gender identity in the survey due the political sensitivity of non-binary gender in China (Häyrynen, 2020). Future research could pay more attention to understanding and supporting the experiences of non-binary engineering students in China.

Another diversity-related limitation of this study lies in the heterogeneity of different engineering subdisciplines. Both my participants and existing literature (Cheryan et al., 2017; Sweeney, 2020) indicate some differences in gender equality among various STEM disciplines and engineering subfields. But this thesis does not engage further in a synthesized comparison among these engineering subdisciplines because the number of participants was not sufficient to cover a wide variety of engineering subfields. There is very limited research exploring this issue in Chinese contexts, so it would be valuable for future research to contribute to this area.

The findings of this research also suggest some limitations related to the intersectionality of gender and SES. As discussed in Sections 10.2.2 and 10.3.2, female engineering students from disadvantaged SES backgrounds might be more willing to accept the so-called ‘dirty’ work in engineering practices, and engineering students from families with higher levels of engineering capital may interact more positively with teachers. Section 10.4.2 also points out that family engineering social capital might be associated with how engineering students develop university-based engineering capital. These three points have limited supporting evidence in this research, so future research is strongly recommended to investigate them in greater depth, as a significant contribution to how gender and SES intersect with each other to shape the experiences, as well as the subject and career choices, of female engineering students.

Regarding the reconceptualization of ‘engineering capital’ in Chinese higher education contexts, the dimensions demonstrated in Table 10-1 are primarily derived from qualitative narratives of participants in this study and Archer’s initial conceptualization. Therefore, quantitative investigations and verifications are necessary to finalise the ‘engineering capital index’. As an extension of my doctoral research, I plan to quantify the ‘engineering capital index’ specific to Chinese engineering higher education contexts after completing my PhD. This practical implementation of the theoretical contributions from my PhD research has the potential to challenge the intellectual dominance of the Global North.

Finally, I would like to acknowledge the impact of Covid-19 on this research. In addition to its influence on the collection of qualitative data, the lockdown during that period in China prevented many students from undertaking internships in engineering-related workplaces. Therefore, this study presents relatively limited data regarding the influence of internship experiences. Now as Covid-19 becomes a thing of the past, future research can investigate with richer data the role that internship experiences play in shaping the career choices of female engineering undergraduate students at Chinese universities.

10.7 Summary

Ultimately, this study has argued that the experiences and engineering-related career choices of Chinese female engineering undergraduate students are largely constrained by prevailing Confucian gender norms as well as the gender monoglossic atmosphere and pedagogy at university, while the engineering capital embedded in both pre-university and university stages can empower female students to take agentic responses to resist the gender structures and head to a career within engineering. This study mainly contributes to existing knowledge regarding women's underrepresentation in STEM from an intersectional and interdisciplinary perspective, highlighting engineering capital as a form of empowerment for female engineering students, and providing a Global South example.

Due to the specific educational system in China and the engineering dispositions they have acquired, several female students have entered engineering undergraduate programmes. However, they frequently face substantial challenges in navigating the gendered power structures found at university. Without external support, such as a gender-sensitive faculty, overcoming these challenges will continue to be difficult for these students. Through the reconceptualization of 'engineering capital' in the context of Chinese engineering higher education, this thesis has argued for developing support for enhanced accumulation of 'university-based engineering capital' for female students and low-SES students. A culturally sensitive framework of university-based engineering capital has the potential to disrupt the reproduction of privileges within the engineering field that are predominantly enjoyed by men from high-SES backgrounds.

Appendix I

Survey

Section One: Demographics

1. How would you describe your gender?
   - ☐ Male
   - ☐ Female
   - ☐ Other
   - ☐ Prefer not to say
2. University information:

1) Type of university attended:
   - ☐ University listed in Project 985
   - ☐ University listed in Project 211
   - ☐ First-tier university (non-985/211)
   - ☐ Second-tier university
   - ☐ Third-tier university
2) Which year are you in for your undergraduate studies:
   - ☐ Year one
   - ☐ Year two
   - ☐ Year three
   - ☐ Year four
   - ☐ Year five (for some engineering subjects)
3) Field of study:
4) Was your current field of study your first choice when you filled in application forms of university?
   - ☐ Yes
   - ☐ No

If no, what was your first choice?
   - ☐ Other engineering-related subjects
   - ☐ Science subjects
   - ☐ Agriculture subjects
   - ☐ Medicine subjects
   - ☐ Art subjects

5) How would you rank your current academic performance among other students in your class:
   - ☐ Top 10%
   - ☐ 10%～30%
   - ☐ 30%～50%
   - ☐ 50%～70%
   - ☐ 70%～100%

3. Family background (This part is very important to my research, so please fill in accurately. The content you fill in will be kept strictly confidential. Thank you so much!)

1) Home city:__________

2) Where is your current family accommodation located?
   - ☐ District
   - ☐ County-level city
   - ☐ Town
   - ☐ Village

3) Parents' highest education level:
   a) Father (or other male primary carer):
      - ☐ High school or secondary vocational school and below
      - ☐ Post-secondary education
      - ☐ Bachelor's degree
      - ☐ Master's degree or above
      - ☐ Don't know
      - ☐ Single parent

   b) Mother (or other female primary carer):
      - ☐ High school or secondary vocational school and below
      - ☐ Post-secondary education
      - ☐ Bachelor's degree
      - ☐ Master's degree or above
      - ☐ Don't know
      - ☐ Single parent

4) Parents' field of study for the highest qualification（this question is exclusive to post-secondary，bachelors , master's and PhD, so when participants choose high school above this question will not appear）:
   a) Father (or other male primary carer):

Which of the following best describe your father's field of study?
   - ☐ Engineering subjects
   - ☐ Science subjects
   - ☐ Agriculture subjects
   - ☐ Medicine subjects
   - ☐ Art subjects
   - ☐ Don't know

   b) Mother (or other female primary carer):

Which of the following best describe your mother's field of study?
   - ☐ Engineering subjects
   - ☐ Science subjects
   - ☐ Agriculture subjects
   - ☐ Medicine subjects
   - ☐ Art subjects
   - ☐ Don't know

5) Parents' job:

   a) Father (or other male primary carer):

      i. Which of the following best describe your father's job?

         ☐ Engineering-related
         ☐ Science subjects-related
         ☐ Agriculture-related
         ☐ Medicine-related
         ☐ Art subjects-related
         ☐ None of the above
         ☐ Not in employment (retired is not included; if retired, please refer to the work he did before retirement)
         ☐ Single parent

      ii. Is it a managerial position?

         ☐ Yes
         ☐ No
         ☐ Prefer not to say

      iii. Could you please specify the exact job?(optional)________

   b) Mother (or other female primary carer):

      i. Which of the following best describe your mother's job?

         ☐ Engineering-related
         ☐ Science subjects-related
         ☐ Agriculture-related
         ☐ Medicine-related
         ☐ Art subjects-related
         ☐ None of the above
         ☐ Not in employment (retired is not included in this option; if your father is retired, please make your choice by referring to the work he did before retirement)
         ☐ Single parent

      ii. Is it a managerial position?

         ☐ Yes
         ☐ No
         ☐ Prefer not to say

      iii. Could you please specify the exact job? (optional)________

6) How many siblings do you have?

   ☐ I am the only child.
   ☐ One
   ☐ Two
   ☐ More than two

7) If 'have siblings', Which of the following statement best describes your situation?

   ☐ I have siblings who work or study in engineering area.
   ☐ I have siblings who work or study in science areas
   ☐ None of the above

8) Which of the following statement of your relatives (other than parents/carers and siblings) best describes your situation?
   - ☐ I have relatives who work or study in engineering area.
   - ☐ I have relatives who work or study in science areas
   - ☐ None of the above
9) How much do you have for monthly living expenses from your parents at university?
   - ☐ Less than 500RMB
   - ☐ 501-1000RMB
   - ☐ 1001-1500RMB
   - ☐ 1501-2000RMB
   - ☐ 2001-2500RMB
   - ☐ 2501-3000RMB
   - ☐ More than 3000RMB

Section two: Science and engineering related experience and beliefs before university

4. Which of the following science and engineering related experiences and attitudes best describes your situation before you went to university? (Moote et al., 2019b; Moote et al., 2020) **(please think back to the experiences and beliefs you had before you arrived at university)**

	Strongly disagree	Disagree	Neither	Agree	Strongly agree
1) A science and engineering qualification can help you get many different types of job.	☐	☐	☐	☐	☐
2) One or both of my parents thought science and engineering subjects are very interesting.	☐	☐	☐	☐	☐
3) One or both of my parents have explained to me that science and engineering	☐	☐	☐	☐	☐

subjects are useful for my future.					
4) I knew how to use evidence in science and engineering subjects to make an argument.	☐	☐	☐	☐	☐
5) My teachers have specifically encouraged me to continue with science and engineering subjects after subject divisions from year 2 in high school.	☐	☐	☐	☐	☐
6) My teachers explained to me science and engineering subjects are useful for my future.	☐	☐	☐	☐	☐
7) It is useful to know about science and engineering subjects in my daily life.	☐	☐	☐	☐	☐

5. Which of the following science and engineering related frequency best describes your situation before you went to university? (Moote et al. ,2019b; Moote et al., 2020)

	Never	Once every few years	At least once a year	At least once a term	At least once a month	At least once a week
1) When not in school before university, how often did you talk about science and engineering with other people?	☐	☐	☐	☐	☐	☐

2) When not in school before university, how often did you read books or magazines about science and engineering?	☐	☐	☐	☐	☐	☐
3) When not in school before university, how often did you go to a science center, science museum or planetarium?	☐	☐	☐	☐	☐	☐
4) When not in school before university, how often did you visit a zoo or aquarium?	☐	☐	☐	☐	☐	☐
5) How often did you go to after school interest-oriented class in science and engineering subjects before university?	☐	☐	☐	☐	☐	☐

6. Who did you talk to about science and engineering? Who are they? (Check all that apply) (Moote et al. ,2019b; Moote et al. ,2020)
   - ☐ Parents or carers
   - ☐ Siblings
   - ☐ Extended family
   - ☐ Friends
   - ☐ Teachers
   - ☐ Directly with scientists
   - ☐ Other, please specify______
   - ☐ No one
7. Did you know anyone who works in science and engineering? Who are they?(Check all that apply) (Moote et al., 2019b; Moote et al., 2020)
   - ☐ Parents or carers
   - ☐ Extended family
   - ☐ Friends
   - ☐ No one
   - ☐ Other, please specify______

Section three: Subjective beliefs in engineering

8. Please tell us more about your feelings about engineering by reporting your agreement to the following statements. (Godwin, 2014)

	Strongly disagree	Disagree	Neither	Agree	Strongly agree
1) I believe learning engineering(specifically my program) will improve my career prospects	☐	☐	☐	☐	☐
2) I believe engineering can help me see opportunities for positive change	☐	☐	☐	☐	☐
3) I believe learning engineering can make me more critical in general	☐	☐	☐	☐	☐
4) I believe engineering is helpful in my everyday life	☐	☐	☐	☐	☐
5) I believe engineering will provide greater opportunities for future generations	☐	☐	☐	☐	☐
6) I believe a country needs engineering to become developed	☐	☐	☐	☐	☐

9. Please tell us more about your behaviors in relation to engineering by reporting your agreement to the following statements. (Meara et al., 2014)

	Strongly disagree	Disagree	Neither	Agree	Strongly agree
1) I have been strategic in enhancing my professional capability .	☐	☐	☐	☐	☐
2) I have intentionally made choices to	☐	☐	☐	☐	☐

focus on an engineering career.					
3) I have seized opportunities when they are presented to me to enhance my professional capability.	☐	☐	☐	☐	☐
4) If I face a setback in the way of learning, I take strategic steps to overcome the barrier	☐	☐	☐	☐	☐

10. Please tell us more about your feelings about engineering by reporting your agreement to the following statements. (Godwin, 2014)

	Strongly disagree	Disagree	Neither	Agree	Strongly agree
1) My parents/ relatives/ friends see me as an engineering person	☐	☐	☐	☐	☐
2) I am interested in learning more about engineering	☐	☐	☐	☐	☐
3) I believe I can understand concepts I have studied in engineering	☐	☐	☐	☐	☐
4) Others ask me for help in and academic learning	☐	☐	☐	☐	☐
5) I can overcome setbacks in academic learning	☐	☐	☐	☐	☐
6) My personal abilities/talents 'fit' the requirements in engineering					

11. Please tell us more about your feelings about engineering and engineers by reporting your agreement to the following statements.

	Strongly disagree	Disagree	Neither	Agree	Strongly agree
1) I believe engineers have to be physically very strong to cope with their work	☐	☐	☐	☐	☐
2) I believe most engineers work with oily machines	☐	☐	☐	☐	☐
3) I believe engineering is not a job for women	☐	☐	☐	☐	☐
4) I believe engineering is a dangerous job	☐	☐	☐	☐	☐
5) I believe engineers are unsociable	☐	☐	☐	☐	☐

Section four: University experience

12. Why did you choose to study engineering?___________________________
13. Please tell us about your experience of learning engineering at university by reporting your agreement to the following statements. (AWE, 2007b)

	Strongly disagree	Disagree	Neither	Agree	Strongly agree
1) There is a reasonable workload in your classes	☐	☐	☐	☐	☐
2) I have positive and frequent interactions with your classmates					
3) There is a fair and inclusive climate in engineering classes	☐	☐	☐	☐	☐
4) I often undertake important tasks in group work	☐	☐	☐	☐	☐
5) Teachers are interested in me and confident in my professional ability	☐	☐	☐	☐	☐

6) I have enough role models in the same gender , who can inspire me as a male/female to work inside engineering in the future	☐	☐	☐	☐	☐

14. When you had an academic problem in engineering, what did you do? (Check all that apply) (AWE, 2007a)
    - ☐ Talk to other students and/or friends
    - ☐ Talk to a faculty member
    - ☐ Spend more time thinking and studying alone
    - ☐ Talk to my parents or siblings
    - ☐ Search online
    - ☐ Do something social or something that relaxes me
    - ☐ Nothing______
    - ☐ Other (please specify):
15. The following is a list of engineering activities. For each activity indicate your level of involvement during the most recent year you were enrolled in university. (AWE,2007a)

	I don't know we have one	Not Involved	1-2 time/ year	3-5 times /year	More than 5 times/ year
1) Activities held by engineering student clubs, such as Technology-lovers Association, on campus	☐	☐	☐	☐	☐
2) Activities for women engineers both on-campus and off-campus， such as Women Engineers Training Camp. (male students can leave this empty)	☐	☐	☐	☐	☐
3) Professional activities or competitions held by the department/ university/nation, e.g. Engineering Drawing Competition	☐	☐	☐	☐	☐
4) Engineering-related undergraduate research experiences, e.g. research seminars，being exchange students as visiting scholar	☐	☐	☐	☐	☐

16. Do you have any engineering-related internship experience during the university?

☐ Yes
☐ No

1) If yes, approximately how many hours per week are/were you employed? (AWE, 2007a)

	Less than 5h	6 – 10h	11 – 15h	16 – 20h	More than 20h
On-campus	☐	☐	☐	☐	☐
Off-campus	☐	☐	☐	☐	☐

2) Please tell us more about any internship experience by reporting your agreement to the following statements:

	Strongly disagree	Disagree	Neither	Agree	Strongly agree
1) I can easily find an internship related to my major.					
2) I had/have more opportunities to access core and professional engineering tasks, compared with other interns.	☐	☐	☐	☐	☐
3) I got/get along well with my colleagues.	☐	☐	☐	☐	☐
4) The internship experience enhances my aspiration of working inside engineering after graduation.	☐	☐	☐	☐	☐

Section Five: Career aspirations

17. Please indicate whether you plan to continue your further studies in engineering (e.g. Master's; PhD):
    ☐ Yes
    ☐ No, I will find a job
    ☐ No, I will continue my study in a different subject
    ☐ Not sure
    ☐ Never think about it
18. If 'Yes', What do you want to do after you finish your master/PhD?

- ☐ Engineering researcher at university/research institutes
- ☐ Engineering teacher at school
- ☐ An engineer at enterprise
- ☐ The non-specialized department of engineering enterprise, such as sales or marketing department
- ☐ Other, please specify_________

19. If 'Yes', why do you plan to continue your further studies in engineering? (Check all that apply)
    - ☐ Engineering job market is not friendly to graduates with a Bachelor's degree
    - ☐ Engineering job market is not friendly to girls and girls need higher diploma to gain similar treatment in job market as boys
    - ☐ Enhance professional ability
    - ☐ My parents suggest me to do so
    - ☐ Follow the general trend of pursuing a master's degree
    - ☐ I want to pursue a PhD to be an engineering researcher
    - ☐ Other reasons, please specify ____
20. If 'No, I will find a job', What do you want to do?
    - ☐ Engineering researcher in higher education institutes/research institutes
    - ☐ Engineering teacher at school
    - ☐ An engineer at enterprise
    - ☐ The non-specialized department of engineering enterprise, such as sales or marketing department
    - ☐ Other, please specify_________
21. If 'No, I will continue my study in a different subject', What subject do you plan to study at PG level? Why?

____

22. With whom did you talk or seek advice from about your decision of career choice (Check all that apply)?
    - ☐ Advising staff on career-seeking related sessions held by university.
    - ☐ Parents
    - ☐ A faculty member.
    - ☐ Classmates and/or friends
    - ☐ Relatives
    - ☐ No one
    - ☐ Other(please specify) _________________

Among the above you've chosen, who is most influential to your career plan?

____

Thank you for your time in completing the survey: I am very grateful.

We will need some female students in their final year of university to attend an interview of about 1 hour to ask some follow-up questions about career choices. You are free to choose to do so online or face-to-face. All communications will be anonymised and your contacts will NOT be disclosed to any third party. If you are interested, please leave your telephone number or WeChat here. Thank you !

Appendix II

The adapted science capital index and the original version

Item-adapted science capital index	Response options and weighting
A science and engineering qualification can help you get many different types of job.	-2 for strongly disagree, -1 for disagree, 0 for neither, 1 for agree, 2 for strongly agree
One or both of my parents thought science and engineering subjects are very interesting.	-1 for strongly disagree, -0.5 for disagree, 0 for neither, 0.5 foragree, 1 for strongly agree
One or both of my parents have explained to me that science and engineering subjects are useful for my future.	-1 for strongly disagree, -0.5 for disagree, 0 for neither, 0.5 foragree, 1 for strongly agree
I know how to use evidence in science and engineering subjects to make an argument.	-2 for strongly disagree, -1 for disagree, 0 for neither, 1 for agree, 2 for strongly agree
My teachers have specifically encouraged me to continue with science and engineering subjects after subject divisions from year 2 in high school.	-2 for strongly disagree, -1 for disagree, 0 for neither, 1 for agree, 2 for strongly agree
My teachers explained to me science and engineering subjects are useful for my future	-2 for strongly disagree, -1 for disagree, 0 for neither, 1 for agree, 2 for strongly agree
It is useful to know about science and engineering subjects in my daily life.	-1 for strongly disagree, -0.5 for disagree, 0 for neither, 0.5 foragree, 1 for strongly agree
When not in school before university, how often did you talk about science and engineering with other people?	-2.5for never, -1.5 once every few years,-1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
When not in school before university, how often did you read books or magazines about science and engineering?	-2.5for never, -1.5 once every few years,-1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
When not in school before university, how often did you go to ascience center, science museum or planetarium?	-2.5for never, -1.5 once every few years,-1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
When not in school before university, how often did you visit a zoo or aquarium?	-2.5for never, -1.5 once every few years,-1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
How often did you go to after school interest-oriented class in science and engineering subjects before university?	-2.5for never, -1.5 once every few years,-1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
Who did you talk to about science and engineering? Who are they? (Check all that apply)	0.5 for parents or carers, 0.5 for extended family, 0.5 for friends, 0.5for siblings,0.5 for teachers, 0.5 for directly with scientists, 0.5 for other, 0 for no one
Did you know anyone who works in science and engineering? Who are they?(Check all that apply)	2 for'parents or carers, 1 for siblings, 1 for friends, 1 for extended family, 1 for other, 0 for no one

Item-original science capital index	Response options and weighting
A science qualification can help you get many different types of job.	-2 for strongly disagree, -1 for disagree, 0 for neither, 1 for agree, 2 for strongly agree
One or both of my parents think science is very interesting.	-1 for strongly disagree, -0.5 for disagree, 0 for neither, 0.5 foragree, 1 for strongly agree
One or both of my parents have explained to me that science is useful for my future.	-1 for strongly disagree, -0.5 for disagree, 0 for neither, 0.5 foragree, 1 for strongly agree
I know how to use scientific evidence to make an argument.	-2 for strongly disagree, -1 for disagree, 0 for neither, 1 for agree, 2 for strongly agree
My teachers have specifically encouraged me to continue with science after GCSEs.	-2 for strongly disagree, -1 for disagree, 0 for neither, 1 for agree, 2 for strongly agree
My teachers explained to me science is useful for my future	-2 for strongly disagree, -1 for disagree, 0 for neither, 1 for agree, 2 for strongly agree
It is useful to know about science in my daily life.	-1 for strongly disagree, -0.5 for disagree, 0 for neither, 0.5 foragree, 1 for strongly agree
When not in school, how often do you talk about science with other people?	-2 for never, -1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
When not in school, how often do you read books or magazines about science?	-2 for never, -1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
When not in school, how often do you go to a science center, science museum or planetarium?	-2 for never, -1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
When not in school, how often do you visit a zoo or aquarium?	-2 for never, -1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
How often do you go to after school science club?	-2 for never, -1 at least once a year, 0 at least once a term, 1 at least once a month, 2 at least once a week
Who do you talk to about science? Who are they? (Check all that apply)	0.5 for parents or carers, 0.5 for extended family, 0.5 for friends, 0.5for siblings,0.5 for teachers, 0.5 for directly with scientists, 0.5 for other, 0 for no one
Do you know anyone who works in science? Who are they?(Check all that apply)	2 for'parents or carers, 1 for siblings, 1 for extended family, 1 for other

Appendix III

Interview schedule

1. What is your field of study at undergraduate level?
   a) Was it your first choice?
   b) How did you make this choice?
   c) Were there anyone else who affected your choice?
   d) What was your choice when facing up with the subject division at the second year of high school? Why?
2. Could you please describe your family background?(Rural-urban area? Parents' job and diploma? Any siblings?)
   a) Do you have family members studying or working inside science and engineering? Do they have any influences on you?
   b) What are your parents' attitudes and practices towards science and engineering?
3. Did you participate in out-of-school science/engineering activities, such as visiting scientific museum and consuming related media? How did these experiences affect your engineering aspiration and choices?
4. How do you feel about your undergraduate life?
   a) Do you have some impressive experiences to share?
   b) What kind of roles did you play in group work at university?
   c) What did you usually do when you had academic problems?
   d) How did you get along with your classmates, especially in such a male-dominated environment?
5. Are there any support for females studying in engineering at your university? Do you have any suggestions?
6. Have you ever thought about changing your field of study at undergraduate level?
7. Having made this choice of subject to learn at university, would you make the same choice again? Or advice female friends to make the same choice? Why?
8. Did you have internship experience inside engineering?
   a) How do you feel about it? Do you have some impressive experiences to share?
   b) How did it affect your career choice/aspiration?
9. What is your plan after getting a Bachelor's degree? Why?
   -If enter the job market: What is your job? Why did choose it? Were there anyone else who affected your choice? How do you feel about this job? How long do you plan to stay in this job? Do you have some impressive experiences in your job seeking process to share?
   -If further study: What is you new field of study? Why did you choose it? Were there anyone else who affected your choice? What is your career plan? Why? Are there anyone else who have affected your plan?
10. How do you think your family backgrounds affect your subject choice, university life,

graduation choice and career choice?

11. Think back from when you first touched upon engineering-related things, and then you got your Bachelor's degree in engineering. Please summarize your story with engineering over the years.
12. Please find some words or phrases to describe yourself.
13. Do you think you are an 'engineering person'? Do you think engineers should be physically very strong? Do you think engineers are unsociable? Do you think women is not suitable to be an engineer?
14. Are there any other factors you think have affected your engineering aspiration and career choice that we have not touched upon?
15. What is your opinion on men's domination in engineering?
16. Do you agree that engineering needs more women?
17. My survey findings show that higher percentage of female students choose to work directly after receiving a Bachelor's degree. How do you think about this? Why do you think the results look like this?
18. My survey findings show that higher percentage of male students plan to choose a career inside engineering after graduation than female students, though the percentage difference is not very large(around 10%). How do you think about this? Why do you think the results look like this?
19. From my survey findings, I find that students from higher SES family tend to have higher possibility to choose inside engineering, though the difference is small. How do you think about this? Why do you think the results look like this?
20. What is 'science' in your opinion?

Specific questions for the six survey participants:

1. How did you feel about the experiences of completing the survey?(All participants)
2. Why do you think engineers have to be physically very strong to cope with their work?(Participants 1-5)
3. Why do you still choose to work inside engineering even if you are not interested in it?(Participant 1&6)
4. I noticed that you wrote in the survey that you almost blindly selected majors based on first impression. Could you have a think about why engineering comes to your first impression?(Participant 2)
5. Why are you interested in engineering? When did your interest arise? Were there anything affecting your mind? (Participant 3)
6. I noticed that you have taken part in activities for women engineers. Could you please tell me something about that experience? (Participant 4 &5)
7. Why you did not choose to Talk to other students and/or friends when you had an academic problem in engineering ? (Participant 5)
8. For the below question in bold in the survey, why did you write 'all'?(Participant 3) why did you write' myself'(Participant 6)?
   With whom did you talk or seek advice from about your decision of career choice, With

whom did you talk or seek advice from about your decision of career choice (Check all that apply)?

- ☐ *Advising staff on career-seeking related sessions held by university.*
- ☐ *Parents*
- ☐ *A faculty member.*
- ☐ *Other students and/or friends*
- ☐ *Relatives*
- ☐ *No one*
- ☐ *Other(please specify)* ________________

Among the above you've chosen, who is most influential to your career plan?

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