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Employment Opportunity Equality in Digital Engineering: A Qualitative Study of Female Graduates' Career Experiences

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Abstract

In the context of the globalized knowledge economy and evolving gender roles, the challenges faced by female career development in STEM disciplines, particularly in electronic information technology and computer science, demand increased academic attention. Despite policies promoting women's participation in traditional science and engineering, the industry penetration rate of female graduates remains not enough in these digital-based engineering fields. This study employs semi-structured interviews with 17 female digital-based engineering students from Chinese universities to explore gender isolation through academic development mechanisms and labor market access. It reveals a "masculine" professional culture within digital-based engineering education, characterized by a cold laboratory environment, male-dominated project models, and gender-biased evaluation criteria, creating a field that excludes women. During market transformations, the intersection of capitalist logic and traditional gender ideologies has fostered a "technical elite-masculinity" narrative, leading to systematic losses of women's educational human capital during employment transitions. However, through social mutual assistance, women exchanged information, formed emotional identities, and accumulated social capital, challenging male dominance in science and technology and exploring gender reconstruction possibilities. The research suggests that while expanding female digital-based engineering education challenges traditional occupational isolation, emerging technologies deepen gender-power dynamics, masking inequality mechanisms through a conspiracy of capital and patriarchy.

Keywords

China; employment difficulties; engineering; gender bias

1. Introduction

The difficulties of women in establishing professional authority within engineering are a global phenomenon. A historical example emerges from Emily Warren Roebling's experience during the construction of the Brooklyn Bridge, where her substantial technical leadership was mediated through her husband's nominal authority (Kranakis, 1997). This historical vignette encapsulates a persistent global predicament: Female authority in engineering remains contingent upon male mediation for institutional legitimacy (Connell, 2005; Faulkner, 2007; Tonso, 2006). The systemic marginalization of women's authority stems from entrenched gender discrimination operating through three structural dimensions. First, post-Industrial Revolution social stratification conflated engineering with masculine-coded attributes such as physical labor and technical rationality, while confining women to domestic reproduction and non-technical service sectors—constituting gendered occupational segregation (Eagly & Karau, 2002; Faulkner, 2009; Harding, 1986; Wajcman, 1991). Second, educational tracking mechanisms in STEM disciplines systematically disadvantage female students. Curricular practices in mathematics and physics often align with male socialization patterns, creating implicit filtration effects at the entry points of engineering education (M. Jin & Hu, 2018; Pascarella et al., 1997; Whitt et al., 1999). Third, media narratives persistently construct technological innovation as masculine genius personified—from Edison to Musk—while relegating female engineers' contributions to "supportive teamwork" or emotional labor. This discursive framing reinforces the cognitive schema of "male-as-innovator versus female-as-facilitator" (Acker, 2006; Rivera, 2012; Williams et al., 2014). Collectively, these institutionalized practices constitute an exclusionary apparatus that perpetuates gendered authority disparities (Cech & Blair-Loy, 2019; Connell, 1995; Cotter et al., 2001; Ridgeway, 2011).

Gender-based marginalization continues to exist across various professions, with engineering displaying unique forms of discrimination that are deeply ingrained in its technical knowledge systems, industrial frameworks, and historical practices (Lagesen, 2008; Ridgeway, 2011; Seron et al., 2018; Tonso, 2007). Core engineering skills, such as mechanical design, programming, and computational analysis, are frequently categorized as "masculine technical mastery," whereas women's proficiency in interdisciplinary collaboration and user-centered optimization is often undervalued as "feminized soft skills" (Bix, 2014; Faulkner, 2007; Hacker, 1989; Hatmaker, 2013; Oldenziel, 1999). The criteria for advancement in the profession tend to favor the accumulation of linear technical capital (e.g., project tenure, patent portfolios), which unfairly penalizes women for career interruptions due to caregiving responsibilities, labeling them as having "professional competence deficits" (Cheryan & Markus, 2020; Margolis & Fisher, 2002; Sax et al., 2017). Additionally, the establishment of trust within engineering teams is frequently facilitated by male-coded social rituals (e.g., alcohol-centric networking, sports bonding), resulting in exclusionary dynamics that deny women significant career advancement opportunities (Acker, 2006; Connell, 1987; West & Zimmerman, 1987). Consequently, women in engineering experience higher attrition rates and face more complex barriers to advancement compared to women in other STEM disciplines. These issues manifest as implicit biases in competency assessments, systemic workplace discrimination, a rapid loss of talent, and enduring glass-ceiling phenomena (UNESCO, 2021).

Globally, counterstrategies against gender discrimination in engineering are advanced through multi-scalar governance frameworks. Structurally, transnational initiatives including the EU's Horizon for Women Engineers establish varying targets, with this specific program mandating a 40% female enrollment in STEM disciplines by 2030 (European Commission, 2021). Meanwhile, Germany's dual vocational system leads the way with gender-targeted apprenticeship programs aimed at recalibrating talent pipelines (Federal Ministry for Economic Affairs and Energy, 2017). Institutionally, Norway's Gender Equality Act imposes a 30% female quota for corporate boards and core engineering teams, challenging traditional meritocratic norms (Ministry of Culture and Equality, 2022). Culturally, IEEE's She Codes in History campaign restores women's previously erased contributions to computing (IEEE, 2025), challenging masculine narratives of innovation. China's approach is an example of state-embedded techno-feminism, which synergizes "scientific power" and "gender equity" agendas. During the socialist era, women entered engineering through state-assigned "worker" identities, which often required suppressing motherhood and adopting masculinized behaviors to gain professional legitimacy (Hershatter, 2011; Y. H. Jin, 2006; Zhang & Liu, 2015). Post-marketization, urban middle-class families utilized private resources—such as extracurricular STEM training and overseas education—to circumvent institutional gender biases (Osburg, 2013; Yan, 2016). Through the Rural Revitalization Women's Action, female technicians have been systematically deployed to rural infrastructure projects, addressing the urban–rural divide in technical capital (All-China Women's Federation, 2025). The 2023 revised Law on Women's Rights institutes a 15% female quota for national engineering laboratories and research and development (R&D) teams (Standing Committee of the National People's Congress, 2023). Additionally, the All-China Women's Federation jointly launched the Women in Science, Technology and Innovation Initiative with the Ministry of Science and Technology and other departments, introducing 16 policy measures (Science and Technology Daily, 2023), while platforms like Douyin and Bilibili promote initiatives like Hardcore Female Engineer to challenge gendered stereotypes in technical fields.

Under China's new-type nationwide system that mobilizes strategic industries, the state has prioritized emerging digital-based engineering education programs aligned with internet technologies and industrial intelligence. Paradoxically, the National Bureau of Statistics of China (2023) reveals that women constitute merely 25% of the technical workforce in engineering—a proportion significantly lagging behind other STEM fields, with even starker underrepresentation in technology-intensive emerging digital-based engineering sectors. This study interrogates two critical puzzles: First, why does gender segregation persist in digital-based engineering fields despite their framing as "future economic engines"? And second, how do female Chinese engineers negotiate structural constraints to cultivate gendered authority within these techno-nationalist projects? Through this dual lens, we examine the dialectics between state-led technological modernization and the reconfiguration of gender hierarchies in China's innovation ecosystem.

2. Methods

This exploratory study utilized qualitative methodologies to comprehensively understand the employment experiences of female students in digital-based engineering disciplines.

The research protocol received approval from the School of Digital-Based Engineering at Wuxi University, following formal review by the institution's ethics review board. The method has been described in detail below to enhance methodological rigor and transparency.

2.1. Study Participants

For this study, the research team recruited 17 female graduates from digital-based engineering disciplines in Eastern China between May and September 2024, primarily through friend referrals and snowball sampling strategies (Sadler et al., 2010). Participants were geographically dispersed across various regions in Eastern China. After receiving comprehensive explanations of the study's objectives and privacy protection measures, each participant provided informed consent both before and during their involvement. The average age of the participants was 20.4 years, with an age range from 19 to 22 years. Most were university students majoring in fields such as electronic information technology, computer science, data science and big data technology, automation digital-based engineering, information science and digital-based engineering, and market operations. Their employment statuses included job-seeking and being employed for at least six months, covering different stages of career preparation.

2.2. Data Collection and Analysis

Researchers conducted one-on-one semi-structured interviews, blending predefined open-ended questions with flexibility to allow participants to freely share their stories and express their thoughts (McIntosh & Morse, 2015). The interviews were led by the two authors, with the first author maintaining continuous oversight throughout the data collection process to ensure data quality. Participants were queried about a range of issues related to education, career, and sociocultural influences, and were encouraged to share their personal stories, experiences, feelings, and perspectives on the difficulties they encountered in job-seeking, particularly concerning employment challenges, gender bias, and experiences of women actively helping each other.

Considering the geographical spread of participants across Eastern China, online interviews were utilized to overcome logistical challenges. Online interviews are increasingly employed in qualitative research, offering benefits over traditional face-to-face methods, such as time efficiency and the capacity to overcome geographic distances without the need for physical travel (Hooley et al., 2012; Janghorban et al., 2014). All interviews were conducted via the online platform Tencent Meeting in Mandarin and lasted between 30 to 50 minutes.

Interview transcripts were transcribed verbatim by the two authors for subsequent analysis. The data analysis followed the thematic analysis guidelines by Braun and Clarke (2006). This process began with a detailed line-by-line reading of the transcripts, which generated several initial codes related to employment difficulties and gender bias. The authors then reviewed, discussed, and synthesized these initial codes into distinct themes (Chui, 2016). Participants' job-seeking experiences, women's understanding of employment challenges, gender biases, and women's active mutual support were organized around these themes, resulting in a coherent and systematic narrative. Pseudonyms were used to protect participants' privacy and maintain confidentiality.

2.3. Ethical Considerations

All participants provided informed consent, with pseudonyms replacing identifiers in transcripts and publications. Data were stored on password-protected servers, accessible only to the research team. The study adhered to ethical guidelines outlined by the university's review board, including voluntary participation and the right to withdraw without penalty.

3. Findings

3.1. Educational Resources, Recruitment Discrimination, and Career-Based Disparities in Gender-Specific Mechanisms Within Digital Engineering

As the industry undergoes rapid digital transformation, the demand for skills has significantly shifted. Feedback from participants has exposed deep-seated systemic biases within digital-based engineering education, which disproportionately impede the workplace preparedness of female students. This section aims to uncover the manifestations of gendered mechanisms in the digital-based engineering field, such as the exclusion of gendered educational resources, gender-based recruitment discrimination, and the gender paradox in career development.

3.1.1. Educational Resources: Gendered Resources and Allocation Disparities

The systemic issues within course offerings have deterred women from participating in hardware experimental courses. For instance, data science senior Lin observed that while her male peers were encouraged to attend the artificial intelligence (AI) deployment lab, she was steered towards a basic course in data visualization. The instructor believed the lab required late-night hardware work, which was deemed "unsuitable for girls." Clearly, this perspective is rooted in gender stereotypes; lacking scientific foundation, it restricts the opportunities for female students to enroll in more advanced courses. Resource allocation is also influenced by gender, particularly in the assignment of laboratory use rights. Consider Wu (Electronic Information Technology, Junior) as an example. When she requested access to the laboratory for circuit design preparation, she encountered overt gender discrimination from the laboratory managers. The manager denied her access to the facility, stating: "You might damage the equipment." Consequently, she was compelled to rely on outdated simulation software for training simulations. This exclusive behavior widens the skills training gap, as male students receive more practical hardware operation training, whereas female students are largely restricted to theoretical simulation exercises. Furthermore, it is important to highlight that gendered social capital and institutional complacency play a role in the allocation of internships: Women are often placed in administrative roles, while men are placed in technical positions. Zhang (Computer Science, Senior) reported: "Industry partners in the department offer only administrative positions to women, and the coordinator stated: 'Companies prefer to recruit male interns for on-site work.'" This practice of assigning women to non-technical roles perpetuates the stereotype of women as supporters rather than innovators.

3.1.2. Recruitment Discrimination: Barriers to Rule-Based Approaches and Screening Logic

Within the digital engineering domain, a pervasive institutional gender exclusion mechanism exists. This mechanism transcends individual prejudice, manifesting in both the explicit "male-first" preference within recruitment protocols and implicit screening mechanisms inherent to competency evaluations.

The explicit exclusion rules and implicit diversion mechanism within the recruitment system collectively form barriers preventing women from accessing core positions. Through quantitative analysis of advertisements for 287 digital-based engineering jobs, researchers discovered that 34% of the positions explicitly stated a "male priority," primarily targeting roles that require "site work" or "equipment maintenance." Lee (Data Science and Big Data Technology, Senior) shared her experience of encountering gender-based job assignments at a job fair:

> I encountered a human resources representative who publicly rejected me, requested that I retrieve my resume, and stated that the technical position would not be recruiting "fragrant flowers," while the male candidates I accompanied were immediately given a live coding test.

This incident highlights the logical connection between technical ability and gender identity: The metaphor of "fragrant flowers" subtly presupposes stereotypes about women's resilience and actual technical skills.

The definition of "job adaptability" by enterprises often becomes an implicit marking of gender discrimination, manifested in masculinity (such as standby status and risk preference). Some participants faced a competency-centered "gender trait assessment." For instance, Zhang (Computer Science, Senior) was criticized for a "lack of strong technical decision-making capabilities" in an AI development job competition, whereas male competitors were praised for their "business competence." Similarly, during an interview with a semiconductor company, Hou (Data Science and Big Data Technology, Junior) was repeatedly questioned about her ability to endure extreme stress. This phenomenon uncovers a gendered perspective on technical competence—women must demonstrate they are "masculine enough" to perform their technical roles, yet they must also avoid being perceived as "too masculine," which can undermine their credibility and create a paradoxical capability dilemma. Another noteworthy discovery is that companies externalize and transfer "birth costs." A human resources representative from a manufacturing company admitted to Hu Tong (Electronic Information Technology, Junior) that "female leave leads to project extensions." Participants noted that the company harbored preconceived notions about motherhood, thereby questioning women's abilities. These requirements are often disguised as safety considerations, as a human resources representative from a manufacturing company stated to Hou (Data Science and Big Data Technology, Junior): "Women's maternity leave affects the progress of key projects, although female candidates pass the corresponding physical fitness test." The following three mechanisms create a negative cycle that exacerbates gender discrimination: (a) Limitations in career development paths confine women to auxiliary roles such as document preparation and testing, reinforcing the gender stereotype of "insufficient technical capabilities"; (b) the institutionalization of salary disparities leads to the perception that pay differences between core and auxiliary roles are a natural reflection of "ability differences," thereby obscuring the impact of structural exclusion; and (c) the scarcity of women in technical leadership roles diminishes the professional aspirations of future female practitioners, fostering a self-fulfilling prophecy.

3.1.3. Career Development: The Gender Paradox in Social Resource Competition

Although women have met academic requirements and achieved proficiency in professional competencies, they encounter considerable challenges in workplace adaptation and career advancement. Specifically, when enterprises demand enhanced productivity from female employees, they paradoxically curtail opportunities for professional development. This deliberate limitation impedes the cultivation of critical skills necessary for sustained occupational growth. Consequently, career advancement becomes a competition for gender-based social capital, compelling women to reconstruct their career capital through informal channels. This phenomenon manifests principally in three ways: First, through the exclusive impact of the safety risk narrative. The company restricts women from participating in core projects (e.g., Zhou is banned from on-site deployment) on the grounds of “factory safety risks“ and “customer acceptance,” which actually deprives them of the opportunity to accumulate key experience. Pang (Big Data Technology, Junior) elaborated on the challenge:

> My team hired three graduates last quarter—all men. When I inquired about the gender disparity, my manager confessed: “We require individuals capable of managing field deployments. The female personnel assigned to the factory encountered resistance, as workers refused to comply with their directives.”

Pang’s case further reveals that male employees naturally gained skill recognition through on-site tasks, while females were excluded from training resources because they were assumed to be “unsuitable.” This has exerted a negative effect—companies refrain from training women, presuming they will encounter difficulties, and subsequently use this lack of training as proof that women are not suited for technical roles.

Second, the phenomenon of gendered social capital monopoly makes evident that career development often relies on informal networks (e.g., men establish relationships with management through after-work drinking activities), while women are often excluded. Career development relies on gendered networks, as Xu (Automation Engineer, Junior) states:

> My male colleagues learn through drinking activities after work with the manager—and I was not invited, “to avoid gossip.” I chose to work overtime at night to study GitHub submission records, but promotions require “cultural fit,” which I couldn’t achieve. A junior male colleague, less skilled than I am, ended up becoming my boss.

Xu’s case study reveals that despite having excellent technical skills, career women may still face career advancement bottlenecks if they cannot adapt to the organizational culture. These implicit social norms transform workplace competitiveness into gendered social resource competitions.

Third, the cost of self-improvement. Women often adopt a “gazing learning“ strategy (for instance, utilizing lunchtime to watch YouTube tutorials or participating in cross-departmental projects), yet the data indicates that they invest more time than men (out of 17 women, 15 dedicate over 10 hours a week to self-improvement, whereas men tend to rely more on company-provided training). Wang, a digital-based civil engineering project manager, proposed the concept of “gender-conscious career capital”:

> I redefined “attention to detail”—a stereotype often used to limit women. Mainly my fluid dynamics precision ensures that the quotation to the enterprise is clear and unambiguous，and this helps me achieve an advantage in negotiations. Now, I guide female engineers to strategically repackage traditionally “feminine traits” as technical advantages.

Although such self-improvement strategies can achieve the desired effect to some extent (for instance, Wang redefined “attention to detail” as an advantage in negotiation), they may essentially mask systemic inequality.

3.2. Mutual Assistance Strategies for Women in China's Digital-Based Engineering Field

This section is dedicated to providing a comprehensive overview of the types of social mutual assistance available to women at various stages of their careers in the digital-based engineering field. Building upon this, we will delve deeper into the connotations at social mutual assistance, uncover elements related to gender discourse, and explore the direction and potential of gender discourse negotiation.

3.2.1. Information Exchange: Challenging the Dominance of Male Discourse

Women in the domain of digital engineering surmount information asymmetry and ability barriers, gaining a sense of control and security, thereby providing capital for their effective engagement with the male-dominated discourse system. Participants stated they joined the Women in Technology group organized by Wuxi University and viewed the group as a "distribution center" for learning resources and a "search engine" for knowledge information. Women in Technology group members have consistently provided a substantial volume of resources, encompassing course recommendations, shared learning experiences, and professional skill development opportunities. The technical knowledge and learning experiences shared by the group members are derived from their personal growth journeys and offer a nuanced and humble female perspective, which circumvents the discomfort that can arise from a male-centric technological viewpoint and also boosts women's confidence in the learning process. As stipulated in the Women in Technology group regulations, "the collective promotes active engagement and reciprocal knowledge exchange, expressly prohibiting derisive conduct towards members." Within the interview materials pertaining to career guidance and experiential sharing, it was observed that female practitioners demonstrate exceptional logical reasoning capabilities, objective articulation, and sophisticated analytical proficiency. Through in-depth analysis of their personal learning history, strengths and weaknesses, needs and goals, they can draw the optimal solution and provide other members with experiences that can be learned from. For instance:

> When selecting a career, you must be proactive. Investigate the role of a product manager, identify the required skills, determine your genuine interest in the industry, and assess your ability to excel in it. Amidst fierce competition, it's crucial to carefully evaluate your strengths. For instance, in non-technical roles, academic qualifications frequently serve as a tangible measure of ability. (Wan, Electronic Information Technology, Junior)

In general, in a technology workplace environment that is male-dominated and lacks female role models, women provide each other crucial support for the struggle for a personal voice and legitimate position in the technology field by sharing their workplace skills with other women.

3.2.2. Emotional Identity: Constructing a Technical Identity With Feminine Traits

Taking into account a shared gender and career background also highlights common experiences, which can encompass challenges such as gender discrimination and limited networking opportunities, thereby strengthening the sense of sisterhood within the digital-based engineering field. Zhao (Electronic Science and Technology, Junior) shares her experience with sexism, which elicited similar emotional responses from other women and expressed her satire regarding the phenomenon: "Men are often encouraged to pursue a better path, whereas women are frequently discouraged by various 'good intentions' when they choose to take a more challenging route." While expressing empathy, women also convey support and encouragement by directly emphasizing the depth and intimacy of emotions. For instance, when observing that female job seekers exhibited insufficient confidence during the interview process, Qin (Electronic Science and Technology, Senior) mentioned that she was inspired by an experienced senior:

> Girls often feel they must meet certain conditions before they dare to submit their resumes. We've been taught to pursue perfection since childhood, rather than being confident. But dear, don't wait until you're perfect enough to try. You are already great, believe in yourself!

On the other hand, the inspired sisters also use phrases like "It's great" and "Sisters are great," fostering a sense of identity among women. Hu (Information Science and Engineering, Junior) expressed her feelings this way: "For me, as long as there are women leading the way and women supporting each other, this understanding is enough to motivate me to continue."

In the domestic environment, the explicit and implicit manifestations of gender discrimination and the imbalance in the gender power structure have become widely recognized phenomena. Consequently, "gender-friendliness" has emerged as an important criterion for evaluating companies and job opportunities. Dou (Internet of Things Engineering, Junior) elucidated the particularities of an all-women working environment, including deep emotional support, rapid growth in self-confidence and confidence, and flexible holiday management policies:

> When I hung out with girls, I felt more, so I was more open to sharing my own thoughts and ideas. The female programmers also provided me with a lot of emotional support. We compliment each other and encourage each other daily, creating a super positive atmosphere!

Interviewer Wu (Market Operations, Senior) shared the experiences of job seekers of different genders during the interview process and specifically highlighted the warm traits exhibited by female candidates. The interviewer also suggested that female job seekers should boost their self-confidence and actively seek opportunities to voice their opinions and showcase their personal accomplishments:

> Every time I finish an interview, I have to share my feelings with my colleagues. I'm deeply moved! The interviews with the girls are excellent. They possess great skills and immediately understand what I'm asking. Their communication abilities are outstanding, and they explain things with clarity. I can sense their reactions as we converse. It's incredibly swift!

3.2.3. Friendship: Acquiring Social Capital Through Relocation

Within the framework of constructivism, network action research elucidates how the social mutual assistance in relationships among actors transform the status and power equilibrium of various entities within social structures. Actors amass social capital through the dynamic interplay of power relations, thereby facilitating the transformation of their peripheral status within the scientific and technological domain and fostering friendships or alliances grounded in shared interests. Given the underrepresentation of women in the digital-based engineering field, society often turns to the experiences of female role models as a crucial reference in education, internships, and career development pathways. Concurrently, there is an expectation that women can shape and influence the creation of rules beyond the macro-policy framework through their perspectives and actions: "Sisters, we must speak up loudly; now is the time to encourage more individuals to rise up and change and establish rules" (Yao, Big Data, Senior).

In the study of feminist technology history and the discussion of female science and technology community activities, establishing women's role models is considered an important strategy to increase women's visibility. Furthermore, women who hold dominant positions in the digital-based engineering field are also contemplating how to foster the further advancement of female members within their teams. Zhang (Electronic Information Engineering, Senior) pointed out that she had secured the opportunity to propose a plan aimed at aiding job seekers in their professional growth, and that she was responsible for leading a small team. Concurrently, she noted:

> Women often lack self-confidence and frequently refrain from taking the initiative to stand up and advocate for opportunities. Even when an opportunity presents itself, they tend to doubt their own abilities rather than seize it immediately. Consequently, I hope to implement training programs designed to help women build professional confidence.

Upon analyzing the motivations of female practitioners seeking social support in the digital-based engineering field, it was noted that the strong camaraderie among male practitioners hindered their ability to establish workplace connections. The online community, exemplified by the Douban group, has notably enhanced the visibility of this demographic, enabling them to "finally find their organization" and no longer feel isolated. These groups offer support to their members by creating spontaneous learning groups. Utilizing social media, these groups achieve a "virtual presence" for their members, thereby converting the weak ties within the Douban group into an interactive ritual chain based on strong relationships within the Douban group. Pang (Computer Science, Senior) mentioned in the interview that during her career transition, she chose to pursue a career in front-end development and thus joined a front-end self-study community. She stated that the female members of the community often encouraged her:

> Initially, I frequently encountered challenging technical issues that were difficult to comprehend, and at times, it was challenging to resolve them independently, which would undermine my self-confidence. Consequently, I joined a front-end self-study group within the community. I was profoundly inspired, and the members of the group were incredibly motivated. When faced with problems, everyone would assist one another, and some even shared their learning progress and plans, which inspired me daily.

4. Discussion

This study uncovers the systemic barriers that Chinese women encounter when entering digital-based engineering fields. These barriers not only reduce their inclination to pursue male-dominated majors but also perpetuate cumulative disadvantages, lowering career expectations and increasing attrition rates in digital-based engineering and technology career paths (DiPrete & Eirich, 2006). The employment challenges faced by women in digital-based engineering fields reveal that, despite China's efforts to address gender inequality through its distinctive institutional framework, gender disparities persist in subtle forms and remain embedded in the nation's modernization process (Wu, 2010). By examining gender discrimination against women in digital-based engineering through the lens of market supply–demand dynamics within a marketization framework, this study also highlights the awakening of Chinese women's gender consciousness and their strategic efforts to establish authority.

From a supply-side perspective, the human capital theory posits that investments in education and skills enhance individual productivity and earnings (Mincer, 1958). However, the disparity in human capital accumulation does not lie in years of schooling but in institutionalized opportunities during university (Li, 2024). Female students in digital-based engineering disciplines face structural barriers to human capital development, such as exclusionary academic climates, male-dominated learning cultures, and unequal access to training opportunities (M. Jin & Hu, 2018). These conditions foster a "chilly classroom" effect—marked by gender-biased evaluation criteria and masculinized success norms—that erodes women's confidence and interest in technical fields (Pascarella et al., 1997; Whitt et al., 1999). Universities often neglect female students' needs in digital-based engineering curricula, while employers disproportionately favor male candidates for internships, further weakening women's competitiveness (Zhu & He, 2016). To overcome information asymmetry and skill gaps, Chinese women in digital-based engineering leverage institutional resources such as Women in Technology groups, alumni referral networks, and online communities (e.g., Douban forums), enabling them to negotiate male-dominated professional spaces and accumulate human capital.

From a demand-side perspective, gender role theory contextualizes the employment challenges faced by female digital-based engineering students within China's shifting gender norms. Following market reforms, official gender equality discourses such as "women hold up half the sky" have lost institutional traction, being replaced by retraditionalized gender roles in labor divisions amid market expansion and media influence (Jia & Ma, 2015; Yang, 2017). Marketization has accelerated this reversal through the erosion of welfare systems and state-led gender equality mechanisms, reinforcing a gendered division of labor (Qing, 2019). The three-child policy exacerbates this trend by emphasizing women's domestic roles, as anticipated maternity leaves and increased employer costs trap female graduates in career–family dilemmas (Lun & Chen, 2024). In response, women in digital-based engineering fields forge collective identities through peer networks, countering discrimination and resource scarcity. They reframe stigmatized traits such as "attention to detail" and "empathy" as technical advantages (e.g., "reducing system error rates") during recruitment, strategically transforming gendered stereotypes into professional strengths.

4.1. Implications

Building on these findings, this study proposes a multilevel framework to address gendered discrimination in digital-based engineering fields shaped by market transitions, technocratic authority, and shifting gender norms. At the macro level, policymakers should urgently revise the Anti-Employment Discrimination Law to strengthen penalties for gender-based hiring biases and implement universal paid paternity leave to alleviate the disproportionate childcare burden on women. At the meso level, universities must strengthen curricular audits in digital-based engineering programs, formally acknowledge the technical equivalence of virtual simulation training, and embed case studies of female technological pioneers—such as Emily Warren Roebling's contributions to digital-based bridge engineering—into course materials. Establishing cross-institutional virtual laboratories could dismantle physical space barriers that disproportionately exclude women. Concurrently, employers should disclose transparent promotion criteria and salary structures for technical roles while adopting flexible work schedules to accommodate caregiving responsibilities. At the micro level, self-organized networks like Douban forums and Women in Technology groups should be integrated into university career development systems to amplify peer mentorship and resource-sharing. These platforms enable female engineers to collaboratively design open-source tools for workplace advocacy—for example, algorithmic systems to detect gendered bias in performance evaluations. Furthermore, leveraging socialist-era collective action traditions, such networks could transform localized resistance strategies into globally connected digital public goods, fostering transnational solidarity among women in STEM fields.

4.2. Limitations and Future Directions

While this study reveals the structural causes of gender discrimination in China's burgeoning digital-based engineering sectors and suggests strategies for mitigation, its applicability is limited by the small sample size. Moreover, the omission of perspectives from male engineers, employers, and policymakers risks oversimplifying the complex mechanisms that perpetuate gendered occupational hierarchies. Therefore, future research should utilize larger and more diverse samples to fully understand the causal mechanisms behind these employment barriers. Further studies are required to systematically explore how regional differences, cultural norms, and economic conditions converge to influence gendered outcomes in technical professions. For example, comparative studies could investigate how industrial policies in coastal versus inland areas or the disparities in urban versus rural educational resources differentially affect women's career paths. Lastly, employing mixed-method approaches—such as combining longitudinal employer–employee matched data with narrative interviews—could shed light on the dynamic interplay between institutional structures and individual agency. This would enhance theoretical frameworks for understanding gender inequality in rapidly changing techno-economic environments.

5. Conclusion

This study provides critical insights into the employment challenges faced by female student and career woman in China's digital-based engineering fields against the backdrop of the nation's techno-nationalist agenda. Through in-depth qualitative analysis, we identify a market-driven reconfiguration of gender discourse—termed "pan-marketization"—that exacerbates systemic barriers for women, including educational inequities, hiring discrimination, career stagnation, and sociocultural constraints. Notably, Chinese women in digital-based engineering are carving out agency within the intersecting forces of techno-authoritarianism and market patriarchy through information-sharing networks, emotional solidarity, and digital community-building. These strategies inherit the collective mobilization ethos of the socialist-era Iron Girls (Y. H. Jin, 2006) while harnessing digital connectivity to forge new resistance pathways. By leveraging grassroots technological praxis, they amplify public discourse on gender equity, sustain cross-disciplinary collective action, and extend solidarity to other male-dominated digital-based engineering fields. Such efforts align with feminist political goals of achieving structural equality and offer globally resonant lessons for techno-feminist movements. China's case demonstrates how localized resistance—rooted in historical collectivism yet energized by digital innovation—can disrupt gendered hierarchies in high-tech industries, providing a counter-narrative to Western-centric models of technological empowerment.

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Conflict of Interests

The authors declare no conflict of interests.

LLMs Disclosure

In this study, DeepSeek was utilized for bilingual text translation during the literature review, findings, and discussion phases. All AI-generated translations underwent rigorous human verification by the research team to ensure conceptual accuracy and terminological consistency with the scholarly context. The tool's outputs were exclusively used as preliminary references and did not influence the interpretation of findings.

References

Acker, J. (2006). Inequality regimes: Gender, class, and race in organizations. *Gender & Society*, *20*(4), 441–464.

All-China Women's Federation. (2025). *Keji Niangzijun Huijiu Xiangcun Zhenxing Xin Juanhua*. https://www.women.org.cn/2025/05/12/99728243.html

Bix, A. S. (2014). "Equipped for life": Gendered technical training and consumerism in home economics, 1920–1980. *Technology and Culture*, *55*(2), 291–320.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Cech, E. A., & Blair-Loy, M. (2019). The changing career trajectories of new parents in STEM. *Proceedings of the National Academy of Sciences*, *116*(10), 4182–4187.

Cheryan, S., & Markus, H. R. (2020). Masculine defaults: Identifying and mitigating hidden cultural biases. *Psychological Review*, *127*(6), 1022–1052.

Chui, W. H. (2016). Incarceration and family stress as understood through the family process theory: Evidence from Hong Kong. *Frontiers in Psychology*, *7*, Article 881. https://doi.org/10.3389/fpsyg.2016.00881

Connell, R. W. (1987). *Gender and power: Society, the person, and sexual politics*. Stanford University Press.

Connell, R. W. (1995). *Masculinities* (2nd ed.). University of California Press.

Connell, R. W. (2005). Hegemonic masculinity: Rethinking the concept. *Gender & Society*, *19*(6), 829–859.

Cotter, D. A., Hermsen, J. M., Ovadia, S., & Vanneman, R. (2001). The glass ceiling effect. *Social Forces*, *80*(2), 655–681.

DiPrete, T. A., & Eirich, G. M. (2006). Cumulative advantage as a mechanism for inequality: A review of theoretical and empirical developments. *Annual Review of Sociology*, *32*(1), 271–297.

Eagly, A. H., & Karau, S. J. (2002). Role congruity theory of prejudice toward female leaders. *Psychological Review*, *109*(3), 573–598.

European Commission. (2021). *Gender equality in research and innovation*. https://projects.research-and-innovation.ec.europa.eu/en/horizon-magazine/gender-equality-research-and-innovation

Faulkner, W. (2007). “Nuts and bolts and people”: Gender-troubled engineering identities. *Social Studies of Science*, *37*(3), 331–356.

Faulkner, W. (2009). Doing gender in engineering workplace cultures. I: Observations from the field. *Engineering Studies*, *1*(1), 3–18. https://doi.org/10.1080/19378620902721322

Federal Ministry for Economic Affairs and Energy. (2017). *Dual vocational training-a recipe for success*. https://www.bundeswirtschaftsministerium.de/Redaktion/EN/Dossier/vocational-training-and-work.html

Hacker, S. L. (1989). *Pleasure, power and technology: Some tales of gender, engineering, and the cooperative workplace*. Unwin Hyman.

Harding, S. (1986). *The science question in feminism*. Cornell University Press.

Hatmaker, D. M. (2013). Engineering identity: Gender and professional identity negotiation among women engineers. *Gender, Work & Organization*, *20*(4), 382–396.

Hershatter, G. (2011). *The gender of memory: Rural women and China’s collective past*. University of California Press.

Hooley, T., Wellens, J., & Marriott, J. (2012). *What is online research? Using the internet for social science research*. Bloomsbury Academic.

IEEE. (2025). *Celebrating achievement and paving the way for progress: International Women in Engineering Day 2025*. https://innovationatwork.ieee.org/international-women-in-engineering-day-2025

Janghorban, R., Roudsari, R. L., & Taghipour, A. (2014). Skype interviewing: The new generation of online synchronous interview in qualitative research. *International Journal of Qualitative Studies on Health and Well-Being*, *9*(1), Article 24152.

Jia, Y. Z., & Ma, D. L. (2015). Xingbie Guannian Bianqian de Duoshijiao Kaoliang: Yi “Nan Zhu Wai, Nv Zhu Nei” Wei Li. *Funü Yanjiu Luncong*, *2015*(3), 29–36.

Jin, M., & Hu, S. (2018). Gongke Zhuanye Benkesheng Xuexixing Touru de Xingbie Chayi Fenxi. *Fudan Jiaoyu Luntan*, *16*(5), 61-69.

Jin, Y. H. (2006). ”Tie Guniang” Zai Sikao—Zhongguo Wenhua Dageming Qijian de Shehui Xingbie yu Laodong. *Shehuixue Yanjiu*, *2006*(1), 169–193.

Kranakis, E. (1997). *Constructing a bridge: An exploration of engineering culture, design, and research in nineteenth-century France and America*. MIT Press.

Lagesen, V. A. (2008). A cyberfeminist utopia? Perceptions of gender and Computer Science science among Malaysian Women Computer Science Students and Faculty. *Science, Technology,& Human Values*, *33*(1), 5–27.

Li, M. (2024). Zhiye Xingbie Geli yu Daxue Biyesheng Qixin Xingbie Chaju — Jiyu CCSS Shuju de Shizheng Fenxi. *Shandong Nvzi Xueyuan Xuebao*, *2024*(4), 33–45.

Lun, R., & Chen, Y. (2024). Shuzi Jingji Beijing Xia de Jiuye Xingbie Pingdeng—Xianzhuang Tiaozhan yu Yingdui Fanglve. *Renkou yu Jingji*, *2024*(2), 1–14.

Margolis, J., & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing*. MIT Press.

McIntosh, M. J., & Morse, J. M. (2015). Situating and constructing diversity in semi-structured interviews. *Global Qualitative Nursing Research*, *2*. https://doi.org/10.1177/2333393615597674

Mincer, J. (1958). Investment in human capital and personal income distribution. *Journal of Political Economy*, *66*(4), 281–302.

Ministry of Culture and Equality. (2022). *Act relating to equality and a prohibition against discrimination (Equality and Anti-Discrimination Act)*. Norway Government.

National Bureau of Statistics of China. (2023, April 21). *Statistical monitoring report of China's national program for women's development (2021-2030) in 2021* [Press release]. https://www.stats.gov.cn/english/PressRelease/202305/t20230508_1939254.html

Oldenziel, R. (1999). *Making technology masculine: Men, women, and modern machines in America, 1870–1945*. Amsterdam University Press.

Osburg, J. (2013). *Anxious wealth: Money and morality among China's new rich*. Stanford University Press.

Pascarella, E. T., Hagedorn, L. S., Whitt, E. J., Yeager, P. M., Edison, M., Terenzini, P. T., & Nora, A. (1997). Women's perceptions of a "chilly climate" and their cognitive outcomes during the first year of college. *Journal of College Student Development*, *38*(2), 109–124.

Qing, S. S. (2019). Zhongguo Xingbie Shouru Chaju de Shehui Wenhua Genyuan—Jiyu Xingbie Juese Guannian de Jingyan Fenxi. *Shehuixue Yanjiu*, *34*(1), 106-131.

Ridgeway, C. L. (2011). *Framed by gender: How gender inequality persists in the modern world*. Oxford University Press.

Rivera, L. A. (2012). Hiring as cultural matching: The case of elite professional service firms. *American Sociological Review*, *77*(6), 999–1022.

Sadler, G. R., Lee, H.-C., Lim, R. S.-H., & Fullerton, J. (2010). Recruitment of hard-to-reach population subgroups via adaptations of the snowball sampling strategy. *Nursing & Health Sciences*, *12*(3), 369–374.

Sax, L. J., Lehman, K. J., Jacobs, J. A., Kanny, M. A., Lim, G., Monje-Paulson, L., & Zimmerman, H. B. (2017). Anatomy of an enduring gender gap: The evolution of women's participation in Computer Science. *The Journal of Higher Education*, *88*(2), 258–293.

Seron, C., Silbey, S., Cech, E., & Rubineau, B. (2018). "I am not a feminist, but...": Hegemony of meritocracy in engineering. *Work and Occupations*, *45*(2), 131–167.

Standing Committee of the National People's Congress. (2023). *Zhonghua Renmin Gongheguo Funü Quanyi Baozhang Fa*. Chinese Government.

Science and Technology Daily. (2023). *Ta Liliang Chengqi Keji Chuangxin Banbiantian*. https://digitalpaper.stdaily.com/http_www.kjrb.com/kjrb/html/2023-11/14/content_562548.htm?div=-1

Tonso, K. L. (2006). Teams that work: Campus culture, engineer identity, and social interactions. *Journal of Engineering Education*, *95*(1), 25–37.

Tonso, K. L. (2007). On the outskirts of engineering: Learning identity, gender, and power. *Science, Technology, & Human Values*, *32*(1), 51–71.

UNESCO. (2021). *To be smart, the digital revolution will need to be inclusive*. https://unesdoc.unesco.org/ark:/48223/pf0000375429

Wajcman, J. (1991). *Feminism confronts technology*. Pennsylvania State University Press.

West, C., & Zimmerman, D. H. (1987). Doing gender. *Gender & Society*, *1*(2), 125–151.

Whitt, E. J., Nora, A., Edison, M., Terenzini, P. T., & Pascarella, E. T. (1999). Women's perceptions of a "chilly climate" and cognitive outcomes in college: Additional evidence. *Journal of College Student Development*, *40*(2), 163–177.

Williams, C. L., Muller, C., & Kilanski, K. (2014). Gendered organizations in the new economy. *Gender & Society*, *28*(2), 262–286.

Wu, X. Y. (2010). Shichanghua Beijing Xia Xingbie Huayu de Zhuanxing. *Zhongguo Shehui Kexue*, *2010*(2), 163–176.

Yan, Y. (2016). *Intergenerational intimacy and descending familism in rural north China*. Cambridge University Press.

Yang, J. H. (2017). Jin 20 Nian Zhongguoren Xingbie Guannian de Yanxu yu Bianqian. *Shandong Shehui Kexue*, *2017*(11), 60–71.
Zhang, M., & Liu, B. (2015). Technology and gender: A case study on "Iron Girls" in China (1950s–1970s). *Technology in Society*, *43*, 86–94.
Zhu, Y. N., & He, G. X. (2016). Xueshu Chanchu de Xingbie Chayi: Yige Shehui Wangluo Fenxi de Shijiao. *Shehui*, *36*(4), 76–102.

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