International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

Gender and Computer Science Debate at Indian Institutes of Technology

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ABSTRACT
This ethnographic study, which spanned seven months, aims to produce a nuanced understanding of the experiences of Indian women students in Computer Science and Engineering (CSE) programs at the Indian Institute of Technology, Madras (IITM) and the Indian Institute of Technology, Kanpur (IITK). The study explores early experiences that motivated the women to enroll in CSE as well as their future aspirations. It also analyzes the barriers to achieving the goals that they expect to encounter. Drawing on 30 life histories of female students in the CSE programs, 40 semi-structured interviews with both men and women professors, deans, and directors, more than 100 informal conversations with men and women scholars, and observational field notes compiled at both IITM and IITK, the major findings from this study of Indian women and their participation in computing are as follows: (1) women do not experience masculinity in the Computer Science (CS) field; (2) CS is considered female-friendly, and women do not report having low self-concept in the field; (3) the CS field in India does not have the stereotypical image of the antisocial geek male, like in the U.S.; and, (4) in most cases, women's elite educational qualifications do not allow them to avoid the orthodoxy of marriage.

KEYWORDS

Gender; Eccles et al. General Expectancy-Value Model of Achievement Choices; sciences; technology; engineering; mathematics, STEM; computer science

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INTRODUCTION

Globally, there is growing concern among policymakers, scholars, and researchers about the sustained low level of women's participation in certain fields within the science, technology, engineering, and mathematics (STEM) group of disciplines. Women's enrollment is particularly low in computer science (CS) programs and has even declined since 2000 in high-income countries. In the mid-1980s, the United States exhibited rapid growth in the number of women attaining bachelor's and master's degrees in CS, but since the 1990s, the proportion of women has been consistently declining (U.S. Department of Education Institute of Education Sciences, 2015). Between 2000 and 2015, the share of CS bachelor's degrees awarded to women in the U.S. declined from 28% to 18%. During the same time, the proportion of master's degrees in CS earned by women declined from 33% to 31%, and fewer than 33% of the doctorates awarded in CS went to women (National Science Board, 2018).

These statistics contrast sharply with current trends of female participation in Indian Computer Science and Engineering (CSE) programs nationwide. Between 2015 and 2018, women were around 40% of enrollees in undergraduate CSE programs and 50% in master's CSE programs at most Indian colleges (Ministry of Human Resource Development [MHRD], 2018). During the 2015–16 school year, around 51% of those awarded undergraduate degrees in CSE programs at universities, university level institutions, and colleges nationwide[1] were men, and 49% were women. For master's degrees, the rates were 44% for men and 56% for women, and for doctoral degrees, 61% of earners were men, and 39% were women (Ministry of Human Resource Development [MHRD], 2016). As discussed by the participants in this study, CSE programs are considered in India to be more elite than ordinary CS programs and lead to better-paying jobs, which gives the impression that higher rates of women graduating from exclusive Indian CSE programs means higher rates of women's participation in the field. Despite this fact, female enrollment in undergraduate CSE programs offered by the Indian Institutes of Technology (IITs) is extremely low, ranging from 8 to 14%. On the other hand, female enrollment in master's level CSE programs at the IITs is close to 50% (IIT Madras, n.d.b; IIT Kanpur, n.d.).

The discrepancy between undergraduate and master's enrollment in CSE programs at IITs could be due to the nature of testing. IIT undergraduate programs use Joint Entrance Exam (JEE) scores to make admissions decisions, and they admit fewer than the top two percent of all annual applicants based on these scores (Leung, 2003). The IIT JEE, one of the toughest undergraduate admissions exams in the world (Joseph, 2012), is conducted in two phases. The candidates first take the JEE Main, conducted by the JEE Apex board in April. The top 150,000 scorers are eligible to then take the JEE Advanced. For both phases of the exam, students must solve complex multiple-choice math, physics, and chemistry problems (IITM,

n.d.b).

The importance of these tests is exhibited by the large number of students who devote two to three years to study for the exam, on top of their schoolwork. Most IIT hopefuls take courses from privately-run coaching institutes (referred to as shadow schools in some countries) during the last two years of senior secondary school, while some coaching institutes start coaching students as early as middle school. According to the participants of my study, it is almost impossible to get through the IIT JEE without tutoring, as the syllabus for the entrance exam extends far past the content taught in high school.

Conversely, the entrance exam for the master's program is based on the undergraduate curriculum alone, and outside coaching is not required. During the 2017–18 school year, nearly 50% of women who took the exam qualified for admission to a master's CSE program at both IITM and IITK. This demonstrates that women can perform equally well as men when the entrance exam is based on the curriculum that is covered in official instruction, which eliminates the need for after-school coaching.

Indian women's positions change drastically based on caste, class, and regional affiliations. Therefore, understanding the achievement behaviors of high-achieving women in a specific cultural context and specific domain provides policymakers, researchers, and educators globally a framework to understand nuances of their own culture that socialize women to believe in the masculinity of the CS fields. This ethnographic study provides a descriptive analysis of the early experiences that motivated women in shaping their "computing attitudes," their experiences with technology, their future aspirations, and the barriers they believe exist to achieving their goals. To address these overarching questions, the following research questions guided this study:

(1) What motivates young women at IIT Madras (IITM) and IIT Kanpur (IITK) to seek education and future employment in CSE?

(2) How are milieu and childhood experiences structured by gender in India?

METHODOLOGY

In this study, I collected life histories of women students and women professors in a CSE program, and conducted semi-structured interviews and more than 100 informal conversations with women students, professors, deans, student leaders, and members of the academic and student senate. I also collected observational field notes at the two IITs where I resided in student residence halls for seven months.

Table 1 illustrates the breakdown of life history and semi-structured interviews conducted at both IITs. Life history interviews lasted one hour to one hour and 30 minutes, and semi-structured interviews lasted about 45 minutes. Some probing questions based on caste, class, and gender overlapped between life history and semi-structured interviews. Life history interviews were conducted to provide

women students and professors in CSE an opportunity to walk the researcher through their childhood, K-12, and graduate school experiences, as well as their decisions to study CSE. In addition, semi-structured interviews broadly focused on how professors, deans, student leaders, and members of the academic and student senate perceived gendered experiences on campus and within a larger sociocultural context. Since women from different states join these programs, interviewing their parents was beyond the scope of this study. Notably, all women participants in this study belong to middle-class of India.

Table 1: Participants in the study

Type of Participant	**Number of Participants**	**Gender**	**Caste**
Life History Narratives			
Students in CSE Program	27 (4 IITM and 5 IITK Undergraduate students; 4 IITM and 6 IITK Masters students; 4 IITM and 4 IITK Ph.D. students)	27 females	2 lower caste; 25 upper caste
Professors in CSE Program	3 (IITM)	3 females	All upper caste
Semi-Structured Interviews			
Deans	10 (5 IITM, 5 IITK)	10 males	All upper caste
Members of Women's Forum and CCASH, Women in Computer Science Program, Wardens	13 (7 IITK, 6 IITM)	10 females; 3 males	All upper caste
Members, secretaries, and speaker of the SLC, members of the student constitution redrafting committee	12 (7 IITM, 5 IITK)	3 females; 9 males	10 upper caste; 2 lower caste
Student Leaders	5 (3 IITM, 2 IITK)	1 female; 4 males	All upper caste
Informal Conversations			
CS Engineering Graduates (graduated in 2016)	3 (IITM)	3 females	All upper caste
Engineering students and professors	100 males and females		

		Total female participants: 47 Total male participants: 26	

I used Carspecken's (1996) coding structure, defined for critical ethnography, to analyze the data. I created two spreadsheets with low-level and high-level codes. Following the interviews, I went back to my audio recordings and listened to each interview carefully to determine if any follow-up questions were needed. I scheduled follow-up interviews via Skype with selected participants to further clarify some of their answers to my questions. Then, I continued to categorize and cluster comparable codes into groups to construct a pattern and to conduct further analysis.

GENDERING EXPECTATIONS: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Over the last decade, scholars have begun to compare the experiences of American women in CS to those from developing nations (Mukhopadhyay, 2004; Varma, 2009; Varma & Kapur, 2010). Mukhopadhyay (2004) argues that in the Indian context, the most notable feature of the "scientific gender gap is the virtual absence of American-style arguments about male intellectual superiority and female intellectual deficiencies" (p. 476). She argues that in India, women do not experience the masculinity stereotype in scientific fields and instead have a general agreement about the "suitability of computing for women" (Varma, 2009, p. 219). Likewise, Varma (2010), in her 2007–08 qualitative study of 60 undergraduate women students majoring in CS in India, found that across all classes and castes, students did not think that "gender is a deciding factor in who could do well in CS" (p. 268). She further concluded that Indian women are less excluded from computing than American women, and, despite the digital disparity due to the differences in availability of social and economic resources, CS is considered to be a woman-friendly field in India (Varma, 2010).

In addition, unlike the low self-concept of women in scientific fields in the United States, women in India report having a high self-concept about their academic performance (Escueta, Saxena, & Aggarwal, 2013). Venkatesh (2015) argued that this gender neutrality is associated with family cultures. In addition, she found that the image of the computing field in the U.S. was that of a white male who is a geek and antisocial, but in India, people who study CS are considered intelligent but not antisocial.

However, these views are not uncontested. Women in India are challenged by the existing social structures, in which educational decisions are collectively made by the family. These decisions privilege sons over daughters in terms of financial investment. Varma (2011) also found that the stereotype belief that boys do better in math is still held by some teachers in India. In another study, Varma and Kapur

(2015) found that women faced challenges, in that "lack of access to extra outside coaching, inability to stay late in labs and travel more freely, and limited computer exposure were some of the factors students cited as resulting in gender imbalance in CS (p. 60)."

Furthermore, Varma (2009) conducted a comparative study of CS and computing education in the U.S. and in India and found that in the U.S., more white females were exposed to computers at a younger age than minority females were. In India, on the other hand, most female students interviewed (55 out of 60) did not have a computer at home. They could only access a computer at school, where they faced slow internet connections and unreliable electricity. In addition, Gupta (2019, 2020) argues that the construction of gender identities in informal environments of elite educational institutions is perpetuated to exclude women from advancing in their career. In a similar vein, Radhakrishnan (2009) argues that "women consistently choose to be career oriented, but rarely at the expense of a family life, which is almost always privileged over the stimulation or even the salary a woman may receive in her job (p. 202)".

Some of the findings of this study align with the model by Eccles et al. (1983). In the U.S. context, Eccles et al. (1983) articulated the concept of the Subjective Task Value (STV), which consists of four major components: (1) perceived importance of attainment value of a task (i.e., the relation between the task and one's sense of personal or social identity); (2) the perceived interest in the task (i.e., the enjoyment one gets from performing the task or activity); (3) the perceived utility value of fulfilling short and/or long term goals; and (4) the perceived cost of the task (i.e., what is at stake in pursuing interests). Importantly, self-concepts of ability and the subjective value of a task predict the rate of participation (Eccles et al., 1983). Women's interpretations of the value that they attach to studying math and computer science is a critical component of achievement motivation. In my study, women talked about these values in relation to studying computer science, which included both school and non-school situations.

GENDERED PERCEPTIONS AT THE IITS

Through vignettes, the following section traces women's trajectories to examine the perceived influence of gender role socialization on their decision to study CSE, their experiences with technology, and their future occupations.

Interest/Enjoyment Value

Around 53% (16 out of 30) of the women who narrated their life stories considered their intrinsic interest in the task as a motivator to study CSE. However, during my informal conversations, the participants discussed utility value of mathematics as high in Indian families, which is why parents focus on mathematical abilities of their children early on. Therefore, several of the women may have made efforts to learn math in middle school due to status, prestige, and market value attached to the field. In addition, the utility value of the subject may have outweighed the negative or neutral attitude toward the subject and generated interest in the subject.

Several women (23 out of 30, 77%) recalled being interested in mathematics since middle school and believed that mathematical achievement prepared them for CSE. Many women who decided in middle school that they wanted to study CSE credited their school curriculum for motivating them to participate in computing activities and helping them attain high estimates of their self-ability. One student participant, Swasti, noted:

> The first thing that drove me to computer science was my school curriculum. I was introduced to coding in grade 8. And I just loved it. It was like a game for me. Taking an expression and coding it. It was very interesting and intriguing…Since my grade 8, I was pretty sure that I am going to study computer science.

Many women participants (12 out of 30, 40%) had private tutors since middle school. Three out of the 12 women hired private tutors because they did not work well with their schoolteachers, and 9 out of 12 women had tutors to gain expertise in math. Their private tutor helped them gain appropriate skills to do well in math. In addition, around 73% (21 out of 30) of women in this study attributed their interest in CSE to various means of acquiring computational thinking. Sakshi, a student reported:

> I was lucky to have a private tutor who, with a lot of patience, helped me break a complex problem into various steps. He made the problems look so simple, and I started to see the world around me as an algorithm.

Therefore, the socializer's support and beliefs that included parents, schoolteachers, and private tutors played a critical role in enhancing the interest value of CS assignments. Participants remembered their earliest encounter with computers in middle school. They also recall their association with video games while growing up. As Seema, a student, stated:

> When I was a kid, I underwent surgery…. So, I was bedridden for two months. I had nothing to do … As I told you, I was very active before … so that's when I started playing computer games…. I was very fascinated by video games…. I felt like … only computer science is for me … nothing else.

Meghna, another female student, on the other hand, was not interested in video games. She described her interest in math and computers:

> I never played video games. I found them addictive and a waste of time. So, even though my brothers were interested in that, I was never interested … from the very beginning, I was quite interested in the logical part of mathematics…I was introduced to coding in standard eight, and I just loved it because it was like a game for me, you know. Just taking an expression and coding it. Gradually, the decision was quite clear that I want to get into computer science.

Aparna, a female student, recalled when her interest in computer science began:

> I had a really good teacher in computer science in my school, so he started with basic stuff, like website designing, when I was in class seven…. When I was in class 10, we designed something like a basketball game and tic tac toe, etc., so I really got interested in game development. I wanted to explore further…. In class 12, a few of my friends introduced me to competitive coding … I was kind of sure that I will take up computer science if I ever take up anything.

Kiran, another female student, did not play video games, but attributed her coding skills to playing chess:

> I played chess as a child, where I had to think ahead not only about my moves but also about what my opponent might do. That required a lot of thinking, and I believe that's what helped me when I started coding. It was logic, algorithm, and the result.

Approximately 20% (6 out of 30) of the women in this study believed that the computer games they played in their youth motivated them to study CSE. In comparison, 27% of the women did not play video games but became interested in computer science because of the school curriculum. Two of the women talked about how chess helped them frame an algorithm and that this was one of the reasons they could code. That is, they understood how to keep the end result in mind.

Attainment Value

Eccles (1983) defines attainment value as "the importance of doing well on the task […] [T]he perceived qualities of the task determine its attainment value through their interaction with an individual's needs and self-perceptions" (p. 89). Broadly, attainment value incorporates perceptions of the task's features to confirm "valued characteristics of the self (e.g., masculinity, femininity, competence)" (p. 89). In this study, nearly every female participant considered themselves very smart and liked the challenges of the CSE course. Lakshmi, a female student, reported that she did not depend on others for solutions to any problems she may have. She noted:

> One thing I like about computer science is that you need a computer and the Internet and can solve many things on your own. I did not really depend on others; I could find solutions by myself.

Moreover, at the IITs, the value of an academic task does not only contribute to higher self-concept but also creates a pathway for lower-caste[2] students to move to an upper-caste identity, as general category students (upper caste) are believed to be more meritocratic compared to reserved category students (lower caste). For example, Shweta, a female student, stated:

> I am a SC [Scheduled Caste], but I know I am smart. I do well in my courses, so no one comes to know that I belong to a lower caste.

Doing well on a task moves lower-caste students ostensibly to the general category, enabling them to successfully hide their lower-caste identity and reserved category[3] status, which adds to the attainment value of the task. As discussed by the participants of this study, one cannot identify a lower-caste student by their appearance, thus, students' caste identities are imagined based on their performance in coursework. A few decades ago, lower caste people could be identified through their last name, but in modern times, people change their last names to conflate their identity with upper-caste people (Masoodi, 2015; Sankaran, Sekerdej, & von Hecker, 2017).

Utility Value

Eccles argued that usefulness of the task occasionally outweighs the neutral or even negative attitude toward the subject. For instance, the desirability of a career goal may encourage students to take advanced math classes. Around 47% (14 out of 30) women interviewed considered the utility value of the CSE as a higher indicator compared to the intrinsic interest in the task. The remaining 16 women considered utility value as a medium indicator to study CSE. None of the women considered utility value as a low indicator to study CSE; therefore, the interest and attainment value of women in this study might be confounded with the utility value of the field. For example, Neha, a female student, noted:

> I always wanted to get into an engineering college, but the entrance exams are really tough …both my parents are very involved in my education. Very encouraging…they push me…They made me feel that I am smart and can achieve anything if I work really hard. I used to suffer from a lot of health problems in my childhood, but you know they never told me this is an excuse or something. They pushed me and motivated me and made me feel that this is not a weakness …and eventually when I worked, I did well in math, and it made me feel good to achieve something. It made me feel I am smart, and I can get into an engineering college.

For Neha, performing well in math meant getting into an engineering college was possible, which made the utility value of mathematics high. Therefore, the value of studying math for Neha was the function of both perceived quality of studying math and her goals. The participating women associated utility value with prestige, status, and financial worth attached to the CS fields. Most importantly, CS jobs are attractive for women because, after marriage, they could work from home as well.

Relative Cost

An individual assesses the value of a task in relation to the perceived amount of effort needed to complete the task successfully. If individuals have a correct estimate of the effort required to succeed on a task, the value of the task increases. However, the value of the task decreases if the amount of effort on the task turns out to be higher than estimated. Individuals also estimate the worth of a task based

on the amount of time invested in the task. They make these interpretations based on various activities in which they may be involved. If a student has negative beliefs about failing a task, then the cost is high because the negative beliefs also have implications for self-concept**.** Additionally, if a student somehow completes a task with minimal efforts, then it provides a good reason for the lack of success. For example, "I didn't do better because I didn't try as hard as I could have" (Eccles, 1983, p. 95). However, it is psychologically more costly if an individual does not succeed despite great efforts.

Considering most female students in this study took timely measures to perform better at math and ultimately succeeded, analyzing the relative cost of tasks in which they indulged is difficult. An alternative explanation could be that there is minimal gender bias inherent in math and science (see the section on cultural milieu); thus, women did not consider themselves inferior to boys even when they did not perform well and hired a math tutor to help them get through complex problems. Furthermore, 25 out of 30 (83%) women did not believe that ability is an innate attribute, and they provided examples of socializers' beliefs that encouraged them to believe that consistent efforts would help them get into the IITs. Despite knowing the higher difficulty level of future courses, their parents did not consider them inferior to their male siblings. Whether the socializers' influence helped them reduce the high relative cost of a task is unclear and warrants further investigation.

Finally, women referred to their short-term goals as getting good grades at the IIT and enhancing their résumé to get a good job. Their long-term goals were largely spelled out as, "We want to work even after marriage."

Affective Reactions and Memories

The female scholars [27 students; 3 professors] described varied experiences that generated emotional responses. These included: (1) bad experiences with a math teacher and the positive experiences with their private tutors to remedy the failure caused by their school teacher; (2) the freedom provided by their fathers to take risks and crash the computer, and the emotional support of both their father and mother which encouraged them to do well; and (3) interesting math and computing curriculum in middle and high school and uninteresting instructional strategies of liberal arts courses that drifted them toward STEM fields. None of the women talked about having math anxiety. Overall, they attributed their success to their socializers' beliefs and efforts, such as their private tutor's excellent instructional strategies in a one-on-one environment or their father spending quality time with them.

The differences in individual experiences, as described by the women participants of this study, were mostly extrinsic. For example, a few women reported having moments when they doubted their math skills, which led to their parents hiring a math tutor who instilled in them that effort and ability are not mutually exclusive but rather complementary skills. Therefore, their negative educational affective experiences were remedied by supplying them with appropriate resources (social, emotional, and educational). However, women described their negative social experiences that induced bias, including the presupposition of gender role in the

society, which percolated in the educational setting as well.

Cultural/Social Milieu

While India is a secular country, minority populations based on religion and caste generally suffer from their underprivileged status in society. Around 61% (18 out of 30) of female participants reported that regional identity on campus is stronger than the caste or religious identity because people from the same region speak the same language. In this study, women perceived that their gender identity was not a hinderance in competing with other STEM students and that their regional identities overpowered their gender identity. However, families still prefer to marry their children to spouses in the same caste or an upper caste rather than a caste lower than their own; therefore, in the case of marriage, caste overpowers regional identity and reproduces endogamy. The following section describes the subcomponents of the cultural milieu that mediate women's perceptions of their achievement behavior and value they assign to various tasks.

Social Role Stereotypes: Pink and Blue Syndrome

Both male and female students and professors in the Computer Science Department expressed that the social construct of gender is very different in India compared to the West. Some deans and professors at IITs acquired elite undergraduate education from the IITs and then completed their master's and doctoral degrees in the United States. They returned to their home country after having worked for varying durations of time as professors at U.S. universities or in the technology sector.[4] In many conversations about gender, professors emphasized that Indian scholarship needs to develop its own theoretical framework to discuss gender relation in science. They critiqued the Western construct of gender-based on "pink and blue syndrome," with one commenting:

> When a girl child is born in India, we do not immediately stuff our houses with pink stuff. When I was in the United States, I went to buy a gift for a newborn baby girl, and to my surprise, I did not find any gender-neutral colors in the store. I met with the store manager, and she apologized for the lack of choices. Sadly, many of us are now copying the West by using pink stuff for our daughters and do not realize that consumer culture has its pitfalls. We need to be careful before we are trapped by the companies that are responsible for changing the good practices of our culture to make a profit.

In summary, the participants that critiqued the Western ways of living focused on the gender segregation socialized through toys and prom nights, which are promoted through consumer culture in the West. Of the 20 male deans and 40 female professors interviewed for this study, 14 (8 male deans, 6 female professors) conveyed these thoughts. According to them, Indian culture helps girls gain self-efficacy beliefs that enable them to compete with men in math and science. The absence of the pink and blue syndrome does not contribute to creating gender binaries through symbols in early childhood. They believed that the absence of such gender binaries resulted in gender neutrality in the STEM fields and that both girls and boys acquire self-efficacy beliefs to solve complex math problems.

Geeky Culture

Several deans, professors, and students reported that, unlike Western countries, Indian girls are attracted to nerds. Nerds, typically, immerse themselves in educational content and get good grades. They talked about nerdy males who are popular among female students in high school and at university. Crucially, the image of an ideal groom for women and their parents involves men's scientific education, but it does not establish men's monopoly on technological pursuits. Therefore, Indian upper-caste masculinity can be described by the educational credentials—embedded in meritocracy—men acquire, which organically translates into positions of power. According to several participants in the study, many lower-caste men work hard to get good grades so they can artificially belong to the upper-caste male community. For instance, Ramya, a female student activist, on campus, who raised caste and gender issues, noted:

> I think IIT is a very interesting sight to look at [the] intersection of caste and masculinity. Many of them are proudly…not just brahmins…the upper caste from Rajasthan, they are all like very …they perform their caste rituals, and they are very proud of that, so masculinity is also [a] display of their caste affiliations. And interestingly, with the lower caste masculinity also…its very interesting because they are all aspiring to be upper caste and upper class, so they don't like to talk about it. Recently, I received a message on Facebook from someone. He said he is from [a] lower caste, and he doesn't want APSC [Ambedkar Periyar Study Circle] to talk about oppression, so he does not want to be projected as a victim. He said, I am working very hard, and you don't know about lower caste experience. Don't talk as if we are not literate. We are not oppressed.

Lower caste men are associated with lesser academic acumen as opposed to upper caste men and women at the IITs. When activists raise caste issues, they assume that their admission through the caste quota is being highlighted. According to them, the only way to bridge this gap is to work hard and get good grades. If they get good grades, they can hide their caste identity. Across all the life histories and interviews conducted, several participants explicitly talked about the association of upper caste men and women with meritocracy, some discussed meritocracy in relation to affirmative action policy and that economic status should be given priority over caste in admitting students at the IITs. Surabhi, a lower-caste female, noted:

> Some people believed that I belong to a particular upper caste because I studied well. That itself shows that casteism exists, but apart from that, I didn't experience anything.

Ramya, an upper caste female student, observed:

> When I talk to the dean, I feel safe even when I have different opinions; I am just confident that he will be nicer to me. Because IIT

> has this merit thing, so it also works in positive ways for me because I am an upper-caste Ph.D. student, and I do well in my studies, so I have certain respect.

The participants reconceptualized caste based on merit. Lower-caste students admitted through the process of reservation are deemed less meritocratic as opposed to general category students admitted through the open applicant pool. As several participants discussed, lower-caste men and women can conceal their caste identity if they get good grades. Therefore, geeky culture is associated with upper-caste masculinity and vice versa.

Social Role Stereotypes: Chastity and Marriage as Norm

Indian parents discriminate more when girls attain puberty, and parents worry about their reputation in society if their daughters liberally mingle with their male friends. Many parents do not allow their daughters to spend time with their male friends. As women reach a "marriageable" age, the division of labor further reinforces the dependence of women. Women are expected to abide by a patrifocal family structure and ideology, and gender differences are more visible than ever before.[5] Gargi, a female professor, noted:

> The IIT environment is very supportive, but it's more of the family background…. Parents put many restrictions, so women are unable to go for research. They cannot delay their marriage after a certain age.

Suparna, a female student, observed:

> While we are doing our masters, we are not bothered about marriage. But when we join Ph.D.… then, there is more pressure to get married … then, all those things come into consideration.… What will you do after getting married? …. Expectations of in-laws come into picture.… So, the research could get delayed…. Those things are big hurdles.… Those problems are not there for men … because even after getting married, they can focus on their research, but for females, it is a big thing.

Both female and male professors shared cases of women who did not plan their further studies because their parents wanted them to get married at a certain age. Lekha, a female professor, at IITM noted:

> In south India, a girl does very well academically. . . she is in the top percentile of her class. She goes to an extremely good college. . . she does extremely well there. . . but after that, she must get married and have children. . . I have seen a lot of my female students who are undergrads. . . they wanted to study further. . . but their parents said, "no work for a couple of years, and we are already looking to arrange for a groom."

Participants described that the preservation of the chastity of women is important for them to do well academically and get married at the right age. Several participants shared that both girls' and boys' parents do not allow their children to go out together because they worry that they would get distracted and not focus on their studies. Sanchita, a female student, stated:

> In my coaching institute [shadow school], students were segregated [tracked] based on their ability. I made it to the top section, where I was the only woman student. My teacher did not have any doubts about my brilliance, but he worried that I might be a distraction for boys, and they might not be able to perform to their full potential. No one thought that boys could be a distraction for me.

This study indicates that the burden of maintaining chastity is largely on the woman and her parents. As a result, parents are extremely cautious in allowing their daughters to mingle with the opposite sex. As discussed by the participants of this study, the male population in CSE programs cuts across the entire demography, whereas the female population largely represents the middle-class and upper caste families.

Moreover, if a woman is not married by the time she is in her late twenties, societal pressure on her to get married intensifies. Gender roles are demarcated. Women's work always involves caring for their parents, children, and extended family, as well as their husband's family. The stereotypes in Indian society for women revolve around the characteristics that help a girl find a suitable match for marriage, which is considered a significant liability for parents during the life of the child. The implications of such expectations start even before a child is born, which was evident in statements made by professors when they described selective feticide—that is, families prefer a boy child over a girl child. Female scholars reported that the economic independence of women has contributed to the growth of the middle class but has not been able to challenge the prevailing social structure. Of the 47 female scholars interviewed (8 married and 39 unmarried, all in CS and other engineering fields), 31 women (79%) believed that their parents would arrange their marriage but that they could decline the offer if they do not like the man. Likewise, out of 8 married women, 6 had an arranged marriage, but they had the option to decline the offer if they hadn't liked the boy.

Cultural Stereotypes of Subject Matter and Occupational Characteristics

When asked about the masculinity of the computer science fields and mathematics achievement, none of the female scholars interviewed for this study perceived themselves as less capable than men, and 91% (43 out of 47) of the female scholars in CSE (27 students; 3 professors; 3 alumni) never felt any kind of discrimination at home or in school that would make them think that men can perform better in mathematics and computer science. A male professor confirmed that in the last five years, not a single woman dropped out of the undergraduate program at IITs. However, gender stereotypes often emerge in social settings.

Interviews with several married couples at IITs who acquired the same education from the same elite institution suggest that women tend to quit the workforce after working for a decade. When interviewing some of the men at the IITs, I asked why their wives drop out of the workforce. One replied that "to quit her job was her decision because children were growing up, and she wanted to spend more time with them." A female professor, speaking about women leaving the workforce, said:

> If the child is not doing well, how many people ask the father why the child is not doing well? So, these things need to be corrected in a very big way—joint parenting. Even today, you will find on campus [that] women are taking care of their children, taking them to music class, drawing class. You seldom see men are taking care of their children unless when it is outside of campus, and some of these women don't drive outside the campus. A large number of faculty wives who are capable do not work …[like] architects, PhDs. I am sure if you take the statistic, there will be around 80% [of] women who don't work. There is something I don't understand. It's worst among educated urban women….I think one should do something … volunteer, work from home …but they give up.

In India, several companies are supporting childcare costs (Raghuram, Herman, Sondhi, & Ruiz Ben, 2017). However, in this study the primary reason that women drop out of the workforce, according to one of the female students, is the lack of good daycare centers in India. A female professor stated that "even if there are good daycare centers, Indian families are not prepared to leave their kids, so women have to quit their jobs or sometimes delay their doctoral work." She added, "We, as a society, put too much pressure on our women. If something goes wrong with the child, it's the woman who feels guilty." Additionally, caring for their children, husband, and elders is not within the purview of women to decide. Even though women in computer science perform on par with men, such a sexual division discourages women from aspiring to jobs that are perceived as having long hours. Hence, they often quit the workforce. A female professor indicated that such sexual divisions of labor hinder women's aspirations to become scientists, and it also has a negative effect on the number of publications women professors produce. Seema, a female professor, noted:

> Once you finish B.Tech. [Bachelor of Technology], your parents want you to get married…. Once they are married, many of them are not able to get back to work.

Smita, a female student, stated that they had internalized gender so much that, many times, they do not even recognize that this is a gender issue and that they are being discriminated against. She stated:

> As students, we don't feel that these issues matter because we perform well, but we feel them when we go into the workforce and get married. Many times we either feel guilty about working long hours and try to take up low profile jobs or end up leaving our jobs because

> there is no support system in the society to help us get ahead in our careers; that sets the precedence and men while making leadership decisions wouldn't include women because they also have internalized that women have a responsibility of taking care of their homes and in-laws.

The findings suggest that, in the Indian social structure, marriage defines a woman. Familial obligations continue to be a woman's responsibility. Therefore, for girls, CSE education is lucrative because they can obtain excellent jobs after getting their bachelor's degree, make their marital prospects better, and fulfill their social obligations after marriage. Many parents' views on arranged marriages are changing. For example, if their daughter marries someone for love, they may not object. However, if their daughter does not find a partner while she is in her twenties, the pressure for her to marry someone that her parents chose intensifies.

Furthermore, in Indian society, the male is considered the breadwinner of the family. The wife's occupation in the hierarchy is generally second to her husband's. Her salary is considered an added wage that she can give up should she need to take care of their family. Maneka (a female student) noted that some of her friends' salaries are higher than their husbands' salaries. Still, if their relatives or friends inquire about their salaries, they often suggest that the husband has a higher salary.

Women's Perception of Socializers' Beliefs and Behaviors

Socializers in the Indian context include both close and extended family members, neighbors, friends, teachers, and private tutors. Consistent with the findings from Gupta (2012) and Gautam (2015), the most significant finding of this study is the important role played by the father, many of whom were considered feminists by women scholars.

Socializers' Support in School and Non-School Activities

Consistent with Mukhopadhyay's (2004) study, the findings of this study suggest that Indian parents believe in girls' ability to do well in math and science and do *not* socialize girls into believing that STEM fields are the prerogative of boys. In fact, 97% (29 out of 30) of the female life story participants noted that their parents' trust in their ability motivated them to work hard. That said, many parents who encouraged their daughters to study math and science did not give them the freedom to "crash the computer," said a woman metaphorically. The idea of "crashing the computer" relates to the freedom provided by parents to take risks and to not worry about the results. However, other parents provided emotional support and believed in their daughters' abilities even when they did something drastically wrong. Many women fondly recalled their father's contribution to motivating them to study math and science in middle school, with 34% (10 out of 30) of female scholars specifically mentioning that their fathers are "feminists."

On one hand, several students (21 out of 30, 71%) described their perception as mirroring the perception of the society, which puts women's familial roles before their career despite their high achievement levels in educational pursuits. On the

other hand, some women (29%) shared the exceptional progressive views about gender and social norms, who declined the common social norms and had strong determination to pursue their career aspirations and, thus, did not aim to follow traditional gender and social norms. In summary, Figure 1 represents the primary factors that motivated the women who participated in this study to join the CSE programs at IITM and IITK.

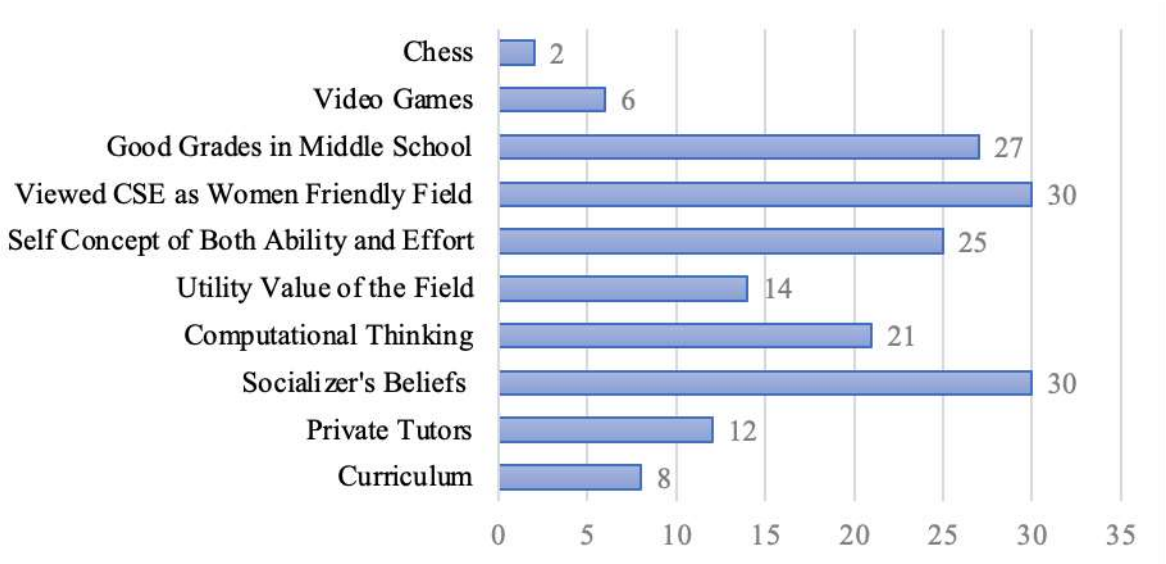

Figure 1: Factors that motivated women to join the CSE programs at IITM and IITK (n=30)

DISCUSSION

The most important mediators that motivated women to study CSE are as follows. First, gender neutrality of the field influenced women to take one of the toughest exams in the world (Joseph, 2012) as well as influenced their high self-concepts of both ability and effort. The female participants in this study did not experience major failure in their lives, and, thus, their understanding of ability and effort are mostly defined under favorable circumstances. Furthermore, when they expected a task to be difficult, their parents (mostly fathers) helped them or hired a personal tutor. Shadow education, linked to social class, played a crucial role in providing a locus of control and computational thinking to the students; therefore, they did not experience learner helplessness about achievement beliefs and behaviors. The women defined their ability and effort based on their grades and their JEE result. Furthermore, they believed that they could enhance their ability with consistent effort. Culturally, hard work is considered crucial to attaining success in any field. As such, they believed that hard work could transform their ability. Their parents believed that the more they practiced, the better they would perform in mathematics. Some students who believed in innate abilities also believed that, to achieve success, hard work is crucial. Importantly, individuals in this study did not view ability in isolation from hard work.

Socializers also played a critical role in female success in CS. The computer science field is considered female friendly compared to other fields (e.g. civil engineering) in India. Female students believe that the support of their parents, teachers, and private tutors enhanced the fun of learning and helped them achieve good grades, which added to their affective experiences of mathematical tasks. Additionally, they were not socialized into playing the so-called "girl games." According to several participants, they did not develop a preference for stereotyped toys. Indian girls, in this study, are attracted to nerds; thus, nerds are popular in high school.

The participants' interest values were developed through a variety of experiences, including computational thinking, which they acquired from instructional strategies, video games and chess, and pedagogy. Given the interdisciplinary nature of computational thinking, they believed that computational thinking should be implemented in schools early on. Some of the women mentioned computational thinking categorically, and others talked about it without using the terminology. Finally, Indian women face challenges when they attain a "marriageable" age, and their familial obligations take precedence over their intellectual pursuits. Several women noted that computer science jobs are lucrative for women because after marriage they can work from home. Their long-term goals were largely spelled out as, "we want to work even after marriage."

CONCLUSION

The findings from this study lead to several conclusions. First, boys and girls are equally exposed to computers during their middle and high school education, and families and communities do not socialize girls into believing that math and science are inherently masculine. One of the primary reasons for women's affinity toward computer science is explained by the sphere of influence of the key socializer. In most cases, the women's father was the key socializer. This type of father did not believe in the "pink and blue" syndrome and, thus, provided educational parity and emotional support to both female and male siblings from early childhood. However, expectancies and values associated with CSE education associated with this finding are about Indian women from a certain social class, whose parents share progressive values.

Second, the cultural milieu influences socializers' beliefs. Furthermore, both cultural milieu and socializers' beliefs influence how women perceive their *own* cultural milieu and socializers' beliefs, which, in turn, influence their expectancies for success and subjective task values.

Third, and most critical, the cost related to a perceived task appeared to be directly proportional to women's marital status. With age, the women struggled with their internalized conflict between their occupational goals and gender roles internalized by them. Therefore, the concept of gender neutrality of the subject matter positively affects their achievement behavior but only up to a certain age.

In this study, the negative effect on occupational aspirations of women was considered solely in relation to marriage because many families believe women

must be married by a certain age. Women's sexuality is recognized by their husband after marriage, but sexuality before marriage is considered problematic, which plays out in complex ways in relation to women's long-term goals. After marriage, family arrangements do not allow women to work for long hours. Therefore, the conflation of science with masculinity affects women indirectly, which often goes unnoticed and unquestioned. Instead, women dropping out of the workforce is considered a natural progression into womanhood and forms a particular conception of women. This is problematic because, in the process of normalizing womanhood, it creates boundaries to serve the interests of more powerful "others" and shapes women's interests and desires according to the power structures created and legitimized by familial relations. Although the trajectory of educational attainment for both men and women overlaps in many ways until women are married, the trajectory changes its form and shape drastically after marriage. Men's equal participation in household chores and parenting is perceived as a far-fetched dream by the women performing on par with men in CSE at the elite IITs. Consequently, women occupy the CSE space with an understanding of the larger social context in which CSE is situated.

END NOTES

[1] Universities and university-level institutions are the institutions empowered to award degrees under an act of Parliament or state legislature. Colleges are not empowered to provide degrees under their own name unless they are affiliated with universities.

[2] The Indian caste system is at least 3000 years old. It comprises four *varnas* (groups), which are further divided into subcategories. Initially, individuals were classified based on their occupation. These categories were: *brahmin*s (priests), *kshatriya*s (warriors and kings)*, vaishya*s (farmers), and *shudra*s (unfree servant) (Dumont, 1980). After India achieved independence in 1947, the caste system was abolished, but prejudice still exists and impacts individuals from lower castes, such as those of the Scheduled Castes and Schedules Tribes (STs) (Pandey, 2011).

[3] In all higher education institutes receiving support from the Indian government, 15% of student seats must be reserved for Scheduled Caste (SC) candidates, 7.5% for Scheduled Tribes (ST) candidates, and 27% for Other Backward Class (OBC) candidates (Sharma, 2019). The phrase Other Backward Classes refers to castes deemed educationally and socially disadvantaged. Nearly half of the student population belongs to a reserved category (Subramanian, 2015).

[4] For instance, Professor R. Nagarajan, Dean of International & Alumni Relations at IITM, completed his Bachelor of Technology at IITM in 1981. He received his doctoral degree from Yale University in USA in 1986 and then worked as a post-doctoral fellow at Yale. He then worked at IBM in San Jose for 15 years and returned to his home country, India, as a professor at IITM.

[5] Mukhopadhyay (1994) the phrase patrifocal family structure and ideology. In a study conducted at technical education institutions to address women's participation in science and engineering, Mukhopadhyay found three major factors that depict a gender gap in science at secondary and college levels: "First, educational decisions are treated as family rather than individual student decisions involving investment of collective family resources and guided by collective family concerns and long-

term goals. Second, gendered family obligations produce gendered educational expectations and goals for sons versus daughters, leading to educational investments that advantage sons over daughters. Third, family concerns about girls' marriageability, social reputation, and family honor make the education of daughters socially problematic" (p. 467-468).

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