Gender Gap in Academia: Perceptions of Female Computer Science Academics

Katrina Falkner
first.last@adelaide.edu.au
School of Computer Science
The University of Adelaide
Adelaide, South Australia,
Australia, 5005

Claudia Szabo
first.last@adelaide.edu.au
School of Computer Science
The University of Adelaide
Adelaide, South Australia,
Australia, 5005

Dee Michell Anna Szorenyi Shantel Thyer
first.last@adelaide.edu.au
Department of Gender Studies and Social Analysis
School of Social Sciences
The University of Adelaide
Adelaide, South Australia, Australia, 5005

ABSTRACT

Despite increased attention from Universities and Industry, the low representation of female students in Computer Science undergraduate degrees remains a major issue. Recognising this issue, leading tech companies have established strong and committed diversity initiatives but have only reached up to 17% female representation in their tech departments. The causes of the reduced attraction and retention of female students are varied and have been widely studied, advancing the understanding of why female students do not take up or leave Computer Science. However, few analyses look at the perceptions of the females that have stayed in the field. In this paper, we explore the viewpoints of female academics and postgraduate students in Computer Science with various undergraduate backgrounds and pathways into academia. Our analysis of their interviews shows the influence of family, exposure, culture, sexism and gendered thought on their perceptions of the field, and of themselves and their peers. We identify that perceptions of identity conflict and a lack of belonging to the discipline persist even for these high-performing professionals.

Categories and Subject Descriptors

K.3.2 [**Computing Milieux**]: Computers and Education-Computer and Information Science Education

Keywords

Computer Science Education, Gender Diversity

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1. INTRODUCTION

The benefits of gender diversity in Computer Science have been intensely studied over the last decade [19]. Existing studies show that a diverse company fares better financially and is more innovative: companies with at least three women serving on the board of directors had, in 2007, a 16% return on equity, as opposed to an average 11.5%; return on sales was 16.8%, as opposed to an average of 11.5% [13]. The presence of women in a team has been shown to be the major predictor of team intelligence, with the teams that scored highest on team intelligence tests having 50% women [28]. However, despite this recognition, and of significant recent efforts in changing curricula [14] and addressing stereotypes [24, 16], the underrepresentation of women in Computer Science still remains a crucial problem.

Currently, about 20% of Computer Science (CS) faculty in the US are female [30]. Top IT companies report lower percentages of women in their tech staff, with Apple reporting 20% [1], Google 17% [11], and Facebook 15% [8]. Many reasons have been identified for female students not picking up CS or for their leaving CS careers once employed. A plethora of studies analyse these issues in detail, including the perception of CS as a male dominated field [16, 25], the lack of identification with the 'geek' stereotype [16], self-efficacy [7], and the lack of organisational support [20].

In this paper, we explore the thoughts and perceptions of high-performing women who have stayed in Computer Science academia, with the aim of identifying the support, family and societal structures, and personal strategies that have allowed them to become successful despite the barriers identified above. The women who are currently working in CS academia are a highly accomplished group who have already survived a series of selections: self-selection following self-efficacy issues as above, unconscious bias and stereotype threat [19], as well as selection from educational and employing institutions. Our analysis of interviews with Computer Science academics and PhD students identifies the influence of family, exposure and culture on the perception that these accomplished Computer Scientists have of the field of Computer Science, and of themselves within the field.

We identify that gender-specific issues relating to the view of who a Computer Scientist *is* persist, and that within this high-performing cohort, concerns over not belonging and fraudulence remain, with stereotypical images of the discipline continuing to define how we see ourselves.

2. RELATED WORK

A large number of studies exist in the literature that focus on the reasons why female students do not take up or leave Computer Science [16, 17, 23]. These reasons include, among others, the perception of CS as a male dominated field [16, 17, 21], the lack of female role models [17, 16], (lack of) exposure to computers early in life [16], media and societal portrayal of CS as a male profession [16, 25], the lack of identification with the 'geek' stereotype [5, 16, 17], and the perception of interest in computers as negative among others. Another key factor is self-efficacy, with studies showing that female students consistently think of themselves as less competent than their male counterparts, despite equal or superior academic performance [18, 27], resulting in a negative perception of CS and computers, and of endorsing and strengthening the stereotype that men are "just better" at CS than women [16, 27].

Self-efficacy, defined as the extent or strength in an individual's beliefs in their capability of successfully completing a task and goal [2] has been shown to contribute to perceptions of career-efficacy in CS and thus to the reasons why female students do not take up or leave Computer Science [15, 17, 21]. Some studies show that females attribute their CS success to chance and hard work; women in CS attribute failure to (unchangeable) inability [16], and take personal responsibility for their failures [16]. Seymour and Hewitt [23] identified a process of discouragement, in which female students consistently doubt their abilities, have a reduced capacity to deal with set-backs and are significantly more dependant on reassurance from peers and lecturers. Moreover, some studies suggest that the perception of self-efficacy decreases over time [27], implying that female CS graduates might end up being less confident of their abilities when they graduate than when they started their CS degree. These symptoms are similar to impostor syndrome, in which individuals feel fraudulent despite being successful in their career or their tasks [10]. Individuals with impostor syndrome will attribute their success to luck, compensatory hard work, and external factors such as physical attractiveness or likeability [6, 10]. They are also highly sensitive to failures in tasks, especially in the case when peers, family and superiors have been consistently praising them: the presence of failure implies that they are not as good as suggested by the praise, therefore invalidating the praise and endorsing the feelings of fraudulence [6].

Few studies have focused on women pursuing an academic career in Computer Science, and thus we include here studies that focus on engineering and science. Among the top 100 US Universities, only 8.8-15.8% of tenure-track positions in math intensive fields are held by women, with full professor positions in engineering only held by less than 5% female [4]. Studies show that the causes of such disparities are numerous and subtle. Valian [26] finds that two concepts drive the disparity between women and men's careers in sciences: gender schemas and accumulation of advantages. Gender schemas are implicit or individual factors that affect males in academia (e.g., unintentional biases, outmoded institutional structures [20]), which lead to males accumulating small advantages that lead to bigger gains. Other studies show that 52% of women in Sciences would leave their jobs at a critical 'fight or flight' moments, and most women that leave academic careers have cited institutional blockage (tenure clock vs biological clock) and gender separation of labor (e.g., women being assigned more teaching) [12].

Fox [9] identifies key social-organizational factors that influence women's progress in academic careers: frequency of talking to faculty about research, ratings of aspects and positions within the department, the department climate, and the levels of interference of family issues on work. The analysis shows that 44% of the interviewed women academics spoke less than weekly about research with people in their faculty, and that women report a significantly lower sense of inclusion, belonging, and recognition received from faculty.

3. METHODOLOGY

In this paper, we undertake a quantitative and qualitative analysis of interviews with female postgraduate students and academics within Computer Science, in order to explore their key perception of gender in relation to their discipline, and their experiences of gender and gender-bias in their transition from student to expert in their field. We explore the identification of their gendered perceptions, including the analysis of the impact of societal, family and peer pressures on their development as Computer Scientists, and their identification as Computer Scientists. The research questions that we ask are: (i) *how do these women see gender as an influence on their perception of Computer Science as a discipline, and on their identity as Computer Scientists?* and (ii) *how have their interactions with society, family and their peers influenced their choices?*.

3.1 Research Method

An instrumental case study is a suitable approach for answering our research question as it allows us to use a particular case as an illustration to identify and elaborate on the perception of gender in relation to Computer Science. Case studies capture the complexities of a phenomenon; such detailed observations cannot be captured in surveys or experimental designs [22]. A typical interview cohort consists of 10-15 participants, to support deep analysis of variation of experience and understanding [3].

This project has adopted a mixed-method case study design where both quantitative and qualitative data were collected. The data were subjected to grounded theory analysis, starting with a process of open coding, before proceeding to axial coding. Grounded theory involves the establishment of a coding framework and analysis environment derived from the data itself. Grounded theory differs from other types of qualitative analysis in that a specific, structured coding framework is not employed. The first stage in grounded theory development is open coding, where the data is broken down into distinct segments in order to obtain the full collection of ideas and concepts present in the data, without regard to how it will be used. Subsequently, axial coding is employed, where the coding framework developed during the open coding stage is refined and reorganised into specific categories, informed by theoretical frameworks and comparison within the data. There are significant advantages in the adoption of a grounded theory approach, in contrast to directed content analysis with an established

coding framework, including removing the potential to force fit observations into existing categories and misclassification.

In our project, we undertook a pilot stage refining an initial set of interview questions derived from the literature, before conducting a series of in-depth semi-structured interviews with our participant cohort. Participants were sought from current female postgraduate students and current female academics within a School of Computer Science, with 12 participants agreeing to participate in interviews of approximately 1 hour in duration. The participants represented a diverse cross section in terms of background, with all but two having completed their undergraduate studies at different institutions, representing a combination of 7 different countries. We refer to all as female academics in the following, with the understanding that the term captures both females who are appointed as academics and those that are on an academic track, pursuing postgraduate studies.

Each interview followed a distinct question sequence, interspersed with relevant follow up questions designed to allow the participants to share their experiences of gender and gendered thought in their perception of Computer Science as a discipline. The questions were deliberately open ended, and asked participants to share their perceptions, and the key influences and reactions from their support groups.

1. What is your area of expertise in CS?
2. What was your perception of CS and ICT before you chose to focus your study in this area?
3. What influenced you to choose the area of CS/ICT to pursue your study?
4. What were your friends and families reaction to you pursuing this area of study?
5. What are the advantages/disadvantages of being in a minority group whilst studying this degree?
6. In what ways do you think CS can improve in order to attract more women into this area?
7. What would you want to say to young women who are considering a career in CS?
8. In what ways has the degree lived up/failed to meet your expectations?
9. Where do you see your future in CS?

The basic unit of analysis in this project was coding units [29], including sections of text responses, of any size. Within the open coding stage, sections of text, such as a sentence, word or phrase, were coded while the selection represented a single idea or concept related to gender and perceptions of gender. In excess of 500 individual interview responses from 12 participant interviews were coded using the qualitative software NVivo (version 10) defining an initial set of 27 distinct codes. The researcher methodically worked through the student reflections, coding their observations either to existing nodes within the framework or to a newly created node, identifying a description of the newly created node and exemplar. During the axial coding state, the researcher worked in collaboration with the project team to iteratively refine the established codes into categories, merging codes where appropriate and in agreement, and identifying discipline-specific categories as derived from the data.

4. QUANTITATIVE ANALYSIS

In their discussions relating to their perceptions and experiences of Computer Science, and the origins of their perceptions, our participants identified several areas associated with gender. Further, the interview participants identified strategies that they felt could act to negate or obviate current negative experiences (total count = 49).

Interview participants identified both positive and negative associations with gender in their perceptions of Computer Science both as a discipline in general and as their discipline of choice, although with a stronger emphasis in the discussion on negative associations. Participants identified positive experiences or beliefs (Table 1) that promoted their sense of belonging within the field, typically associated with their natural talents for STEM (associating with Computer Science or Mathematics specifically), or an interest in creative problem solving. Participants identified experiences or perceptions of positive gendered thought associated within their position in the discipline, typically associated with benefits that they perceived were a natural consequence of their gender, for example, stereotypical beliefs that women were specifically well suited to specific roles needed within the discipline, or benefits in terms of supportive roles they played within discipline teams. The interview participants further identified the crucial nature of external sources of support in their decision to pursue Computer Science as their discipline, with a stronger emphasis on family support.

Table 1: Positive experiences of gender association (total count = 95).

Category	Freq	%Freq
Sense of Belonging	*30*	31.58%
Natural Fit	20	21.05%
Excellence	7	7.37%
Respect	3	3.16%
Gendered Thought	24	25.26%
Positive Support	20	21.05%
Positive Family Support	12	12.63%
Positive Societal Support	8	8.42%
Increased Confidence	1	1.05%

With the majority of gender associations identified as negative, Table 2 presents a broader and deeper range of experiences or perceptions suggested by the participants. Within the negative context, gendered thought appears as a dominant factor, where participants were freely identifying multiple examples of negatively-associated gendered perceptions of ability within Computer Science, or aptitude for STEM as general area. Participants clearly identified the *lack of a sense of belonging* as a negative experience - in their negative discussions of this category, participants primarily discussed specific examples of feeling isolated, or at odds with what their perceptions of a Computer Scientist should be or act like. They reported experiences or perceptions where they indicated a sense of fraudulence - where they were not really acting as a Computer Scientist should, or not achieving results similar to their male counterparts - a surprising emphasis given the highly competent and successful nature of

the interview participants, however consistent with previous studies on imposter syndrome [10].

Table 2: Negative experiences of gender association (total count = 204).

Category	Freq	%Freq
Gendered Thought	*57*	27.94%
Sense of Not Belonging	*57*	27.94%
Identity Conflict	35	17.16%
Fraudulance	19	9.31%
Unnatural Fit	3	1.47%
Negative Support	*41*	20.10%
Sexism	20	9.80%
Negative Societal Support	15	7.35%
Negative Family Support	6	2.94%
Perception of Challenge	24	11.76%
Gender Imbalance	19	9.31%
Lack of Confidence	6	2.94%

Negative support was also a significant contributing category in the interview discussions, including explicit identification of sexism or sexist behaviour within the field, and negative feedback or messages from their society and their families. Participants discussed Computer Science as a field with many challenges, and clearly identified gender imbalance as a significant and visible issue.

5. QUALITATIVE ANALYSIS

5.1 Influence and Support

The interviewed academics identified a range of positive family and societal support that allowed them to pursue a career in Computer Science. Participants reported that it was the economic benefit of the field that drove their families in supporting or encouraging them to become Computer Scientists. Careers in Computer Science are seen as "good jobs", with a "good future" and thus parents strongly encourage their daughters to pursue them:

> "My parents choose this topic for me, because it was very hard, and they knew that I could get a good job out of this."

Another driver for the positive family support is the perceived novelty and value of technology; however, specific benefits of technology are not identified nor used as drivers for support. One participant notes:

> "(my father) thought this was the thing to do. He could see this was an excellent area for future development."

while another observes:

> "My parents are from the commerce side, but they are very interested in the new technological things."

Computer Science is similarly perceived in society as a "good" career to be in, as a participant notes:

> "They see IT as an excellent path for anyone to go into; engineering and IT are definitely seen as being a good career to be in."

It is important to highlight that the drivers for positive support to pursue a Computer Science career are very broad, and are focused on the perceived economic benefits or the novelty of ICT. In contrast, the discouragement received by participants is gender specific, with family or society perceiving that Computer Science is either not a suitable career for a female, or that other, more suitable careers, such as teachers or doctors, exist:

> "My parents wanted me to do something like physics, and they wanted me to become a teacher."

or, as another participant notes,

> "My mother was very keen on me doing medicine, she thought that was a good job for a girl."

In other cases, the negative support is focused on ensuring that females focus on building a family and a home, at the expense of building a career:

> "There is still an attitude with many societies, that women stay at home."

Moreover, the simplified perception of Computer Scientists does not match traditional gendered expectations:

> "you are expected to get married, not sit in front of a computer."

There is also a conflict between work-life balance in an academic career and the various family-building pressures:

> "My parents are still not happy. Because I will be doing research for 5-10 years and only work on that. They would like me to get married, have children."

5.2 Identity and Sense of Belonging

We found a similar contrast when looking at positive and negative identification with Computer Science, in that the positive association with Computer Science was typically very broad, whereas the negative associations are generally Computer Science specific and more gendered. The ability to perform well in Maths and STEM disciplines in high-school was perceived by many as one of the main positive association points with Computer Science, as one participant notes:

> "I was good at maths, I have always been good at maths."

For another participant, there is a sense of pride associated with being good at a difficult subject such as mathematics:

> "I liked mathematics, so computer sciences has a good relationship with the mathematics background so I was rather interested in the theoretically side of computer science. That is the reason I chose computer science, because it is like a realisation of mathematics (...) the mathematics stream is very hard. It is difficult to get in."

The negative associations to Computer Science focus on perceived gender-specific traits that are seen as incompatible with the Computer Scientist identity. These include working with people, the perceived lack of coding skills in females, but also the way the Computer Science field views female interests. One participant notes that her desire to communicate and interact is incompatible with the Computer Science identity:

> "I like working with people. That's a disadvantage for me with Computer Science."

For another participant, this gendered perception of women as good communicators has undesired outcomes:

> "The assumption was that women are good at customer service, with me being more technical though, I seemed to be pushed into areas I didn't want to pursue."

The perception that female-associated traits or desires are not suitable to Computer Science extends beyond communication and working collaboratively:

> "The things that attract women are seen as lesser (...) What I see is engineers putting down 'Human Factors'. One of the greatest challenges is touch screen, how we use things, but its put down as less important than say networking or operating systems."

In some cases the participant herself suggests that females are in general not technically skilled, but that regardless there are opportunities within the field even for them:

> "It's probably best to attract people who are technically skilled. Trying to attract people who are not good at that area, is really not a good idea. I suppose to attract more women, you have to inform them about what computer science actually is, it's more than technical there are a whole range of different activities within Computer Science you can be part of."

The above stereotypical views of Computer Science and of the 'geek' or CS identity imply that these accomplished Computer Scientists will always view themselves as outsiders, both through their own thoughts, but also through the actions of others. The Computer Scientist who knows she is technically skilled will not belong in the group of other female Computer Scientists, by default perceived as having less skills; the communicator who likes to work in large projects does not feel accepted by what she perceives is the Computer Science culture; the human factors researcher feels that her work is not important and not accepted by the community because it is not 'geeky' enough.

5.3 Imposter Behaviours

The lack of a sense of belonging and of a positive identification with Computer Science also leads to imposter behaviours, with 67% of participants reporting feelings of fraudulence. In some cases, the imposter thoughts are gendered:

> "The girls are always doing documentation you have nothing to do with the implementation. You just write things. The boys do things quicker than us."

Another participant's imposter thoughts are focused on the need for persistence, hard work, and luck to have a successful career:

> "Don't be afraid of the competency of the men, because sometimes you can think better than the men. I think if you persist you will have a good future, you are the minority group and sometimes they want the females."

whereas another participant focussed on likeability as a key to success:

> "I think the best part is that you are always a princess. It is very simple to communicate with a male, and they like to help you. It is a very good atmosphere."

Around 40% of participants reported on the need of flawless excellence to either succeed or to feel that they belong:

> "I think, it is similar in other fields that women are not always as powerful than men, unless they are very excellent they cannot achieve that level."

6. DISCUSSION

An identity for Computer Scientists that is at odds with how women see themselves presents a significant problem for our discipline. Research has demonstrated that lack of alignment with stereotypes - the image of the discipline - can have a significant, negative impact on recruitment strategies [5], despite gender. Specifically, women and men who embody the stereotype of our discipline may struggle to recruit those that see themselves as *other*. However, with promise, research has also indicated that offering a different image of a group that is a better fit, or more closely aligned with self image, may encourage others to consider themselves becoming part of the group.

While the participants in our study were aware, in general, of the gender imbalance within the field before entering it, they did not see this as a significant issue. They had confidence in their abilities, stemming from their capability in related STEM areas, and fostered by family support associated with financial and stability means. However, their experiences within the discipline have resulted in the development of a clear identify of the discipline that does not represent who they are. This result demonstrates that our embodiment of stereotype, in many cases associated with gender, associated with our discipline is not just an external perception, but is a present and clear issue *within* our discipline.

In our interviews, we asked participants to identify what they saw as possible strategies to address these concerns. In addition to expected commentary regarding recruitment and mentoring opportunities - of which we are supportive - participants consistently identified the lack of a clear identity as a concern. The most prevalent focus in the discussion of strategies, identified by 80% of the participants, was on defining and effectively communicating what Computer Science is. The main points identified as part of a Computer Science identity are problem solving, and the fact that it is more than 'technical' coding. One participant notes:

> "I suppose to attract more women, you have to inform them about what Computer Science actually is, it's more than technical"

This lack of a clear, positive message from our discipline has resulted, in their perception, in continued attention to negative, media-driven stereotypes. This represents a further call for action to challenge, both without and within our discipline, the image of our discipline, and behaviour within our own environments that narrows our perceptions of who we are.

7. CONCLUSION

In this paper, we have presented the analysis of interviews with a range of female academics and near academics in Computer Science, identifying persistent gendered perceptions of their discipline and their place within the discipline. We have identified that although confident in their general capabilities in STEM, lack of confidence in their specific abilities within Computer Science pervades, and that the image or sense of identity of what it means to be a computer scientist conflicts with how these women see themselves.

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