Exploring women's motivations to study computer science

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Publication date:
2018

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Abstract — This paper presents a study exploring women's decisions, influencers and early experiences of computing to better understand how women's motivations and prior experience affect their decision to study computer science (CS). The emergence of a gender balance target and government imperatives for Scottish university courses has challenged computer science as a discipline across the 14 universities in which computing is currently taught. The funding body target is that there should be a more equal gender balance, with no course having fewer than 25% of one gender, leading to a proliferation of gender action plans across the university sector. Of course the phenomenon of under-representation extends across developed countries in the west, albeit with a small number of high profile resource-intensive interventions making headway. At present the percentage of women studying computing in the UK is 17%. The lack of female applicants to courses suggests that subject decisions have been made through previous experiences prior to selecting a course and university. Surveying current computer science students (n=185) we explored women's and men's reasons for studying computer science, their influencers and their early experiences of computing. The aim of the study was to examine the motivations and influences that led them to a positive choice of computer science in order to find evidence on which to build a gender action plan. We found that women were introduced to computing at different stages (including home, early schooling and secondary schooling), whereas men were more likely to have been introduced to computers at home. Women also cited slightly more varying reasons for selecting CS, while men were more likely to select it based on personal interest. Both men and women were influenced by friends and family. However, men were slightly more likely than women to make the decision to study computing by themselves, not citing any other influence. The paper reviews the literature on women studying CS and describes the study and findings. It is hoped that this initial work can help universities better understand the nature of the challenge and target resources in the right places to encourage more women to study CS.

Keywords— women, computer science, motivations, Rational Choice Theory

I. INTRODUCTION

The gender imbalance in the IT sector in the US, UK and elsewhere persists in spite of much research and many initiatives. Why does it matter that women are under-represented? Distilling a decade of research, Trauth [1] identified five reasons why women should be better represented: i) to increase innovation capability and capacity, ii) to serve women as tech consumers, iii) to create a bigger pool of talent to fill jobs, iv) economic security for families and iv) equity of 'opportunity to pursue all careers' (p. 2). For many reasons, the current situation is undesirable.

In Scotland, a Gender Action Plan sets forth the ambition to have no university courses with fewer than 25% of one gender [2]. In the UK there are many higher education options, including choices of region, university, discipline and course. Rational Choice Theory (RCT) posits that individuals make choices based on a consideration of the outcome of different decisions, taking into account the likelihood of success of a particular action [3]. Of course, university course choices are not entirely freely made. Options will be ruled out such as those based on access to economic capital to study away from home or meeting pre-requisites for courses. Presented with a first year cohort of computing students, this study explored the reasons behind women's and men's decisions to study a computer science major at university, in contrast to much of the literature that determines why women decide *against* a CS major.

This paper presents an overview of the literature on gender imbalance in computer science, describes the study and findings and then discusses the findings in the context of RCT to seek better understanding of the factors in making a decision to study computer science.

II. LITERATURE REVIEW

Studies have related the phenomenon of a lack of women in the ICT sector to a shortage of women role models (for example [4]; [5]), perceptions of the characteristics of CS students such as 'geekiness' and introspection (for example, [6] and [7]), perceptions of cultural characteristics of the workplace environment including being riddled with misogyny or alternatively somewhat patronizing [8] and finally perceptions of the work such as low status jobs with jobs under threat of outsourcing and offshoring [9].

In terms of sector retention, when women do study computer science and enter the ICT sector they are twice as likely to leave than men (termed the 'leaky pipeline'), attributed by Main & Schimpf [10], to "work-family conflicts, the occupational culture of computing fields, and limited mentoring and networking opportunities", and for reasons such as lack of flexibility in contracts, expectations of excessive hours and lack of recognition within their employer's organizations [11]. Despite the best efforts of outreach initiatives (for example, [5];

[12]), the gender imbalance in the UK, as elsewhere, remains pronounced. The underlying principles of many well-meaning interventions have now been questioned, for example, Frieze & Quesenberry [13] raise a concern that the essentialist approach which promotes gender-specific messages is hampering progress, indeed, counter-productive. They recommend embracing diversity rather than attending to gender differences as a means to effect a culture change. Overall, there is a lack of critical evaluation [14] so the effectiveness of interventions is not widely known.

Under-representation of women in the sector starts with computing education. Constituting only 17% of UK computer science students, women remain chronically under-represented on computer science courses [15]. Recruitment and retention of women in computing majors, in the UK, Australia, Europe and the US, remains an ongoing project in spite of many high-profile interventions (for examples see [14]). Indeed the near-future looks bleak in Scotland, UK as girls are less likely to study computing at school than boys with only 20% uptake by females in the initial national computing award taken when approximately 16 years old (Nat 5), reducing to 12% in Advanced Highers taken 2 years later [16].

Baker [17] summarizes research efforts to explain equity issues in global science education leading to fewer women than men in science, concluding that school, home and cultural influences combine in varied and complex ways to deter women from life as a scientist. Hur, Andrzejewski, & Marghitu [18] found that, amongst girls aged 10-16, very limited knowledge of and experience with CS, coupled with a lack of confidence in their CS capabilities, led to less uptake by women in CS education. Sadler, Sonnert, Hazari & Tai [19] found that girls' interest in a STEM career declined during the high school years from a low base (15.7 to 12.7), whereas the percentage for males remained stable (from 39.5 to 39.7). Perception of a lack of ability and low levels of self-esteem amongst women were also identified by Schinzel [20] as factors affecting uptake. Kinnunen, Marttila-Kontio & Pesonen found that many male Computer Science first years have had programming as a hobby prior to university [21]. Indeed, Margolis and Fisher have long argued that the forces by which women and girls begin to be locked out of the "all-boy clubhouse" of computer science begin to take effect from early childhood with the gender difference in toys and game playing [6]. Women have been found to have a less playful attitude towards computing, and girls are less likely to play with spatial and science-related games and toys than boys [22], with boys spending more time interacting with age-appropriate technology activities [23]. Master, Cheryan, Moscatelli, & Meltzoff [24] argue that this contributes towards a lasting technology motivation and self-efficacy gender gap. This experimentation leading to early notions of mastery might affect women's decision-making so enquiring about early experiences formed one of the questions of this study.

Lewis, Anderson and Yasuhara [25] identify five major factors influencing the decision to major in CS: potential students' experience and expectations of success as CS majors; the extent to which their own values and identity align with values and cultural expectations they associate with CS; how much they believe they would enjoy majoring in CS; the utility of CS and the extent to which CS would provide potential value to society or to them as individuals; and finally, practical constraints and ways in which majoring in CS might restrict other plans. Rodriguez and Lehman [26] argue that the second of Lewis & al.'s factors, values and identity, are a strong driver for women to embark on CS degrees. According to Rodriguez and Lehman, female students' experience during first year CS informs their computing identity; their persistence in computing can be threatened when they have experiences in computing that they cannot integrate into their personal identities. Google reported social encouragement, self-perception of ability, academic experience and perception of careers as factors in positive selection of CS for women [27].

In a cross-country study, De Lara and Liu [28] found positive reasons to study computing were interest and enthusiasm for computing, high levels of self-esteem, a 'stubborn attitude' (p 15) and a feeling of passion for science and technology. Decision-making in less gender-equal countries is more likely to be based on life-quality improvement [29] which is reflected in the higher numbers of women studying computing in, for example, India, Malaysia and Vietnam. In comparing STEM degree take up by women in Australia and those in East Asian countries, Marginson, Tytler, Freeman, & Roberts [30] describe university STEM degrees in Australia as accessible only to students with high school qualifications *and* 'talent' in science and mathematics. They argue that this is the opposite of the idea prevalent in East Asian countries, where "success in education and science is due less to talent than to hard work". Of interest, is how these factors interact to affect decision making.

Whatever the reasons to select CS, there are also reasons why CS is not selected. For example, Leslie, Cimpian, Meyer & Freeland [31] suggest that the extent to which practitioners of a discipline believe that success depends on typically male innate brilliance is a strong predictor of the degree to which their discipline excludes women and minorities. Similarly, studies have shown that females can lack confidence, presenting a potential barrier. In their 33-question attitude survey of first year CS majors, Settle, Lalor & Steinbach [32] found that the largest difference in response between males and females is seen on questions relating to confidence, with females *less likely* to report that they were sure they could learn programming; they were also less likely to be sure they could do advanced work in computer science. Their responses indicated low self-efficacy regarding their ability to handle more difficult programming problems and belief that they could get good grades in computer science, and a lack of self-confidence when it comes to programming. Beyer [33] argues that "if women believe that careers in CS do not reflect their interpersonal values and satisfy their life goals or interests, they should not desire to pursue a CS major, even if it can lead to lucrative careers" (p. 156).

Attitudes to studying CS are affected by the way CS is promoted through open days, for example how coding activity is described. Kirkpatrick [34] quotes a female computer science professor involved in women's hackathons who describes the competition model as discouraging diversity of thoughts and approaches, including the team-based development model preferred by female students. Beck & Chizhik [35] suggest that switching to small-group co-operative learning or pair programming means the problem-solving process becomes more supportive and less competitive. Sobel, Gilmartin, & Sankar recommend reducing class sizes and not putting new, inexperienced or female students in with (mostly) male programmers with years of experience [36].

For the purpose of this study, Rational Choice Theory (RCT) was identified to introduce a theoretical framework. RCT has previously been widely used in economics to consider individual behavior (for example, [37]). The theory examines how an individual's choices interact to produce outcomes. The theory posits that observed action (for example, joining a computer science course) is caused by reasoned decisions; the reasoning is based on a consideration of the consequences, largely to the individuals themselves, of the action; individuals weigh up alternative courses of action and finally, select the one they perceive as having the most favorable outcome [38]. RCT has previously been used in educational research to model student decision-making (for example, [3]; [38]). Perceived likelihood of success has also been considered when approaching educational decisions (for example, [28]; [29]) and found to act alongside cost and benefits in determining a rational choice.

A criticism of RCT is that it is generally applied to consider in the main monetary transactions, i.e. approaching studies believing that individuals 'maximize only material goods and money' [39, p. 30]. RCT also assumes all possible costs and benefits can be analyzed consciously and reasonably effectively. In terms of research approaches, Kroneberg and Kalter [40] found that researchers evaluate choices either by surveying individuals about expectations and perceived advantages and disadvantages; or indirectly, by measuring individuals' actions. In this study we explored choice directly by asking how decisions had been made in order to gain insight into motivations and perceptions of women on CS courses.

Attempts to design research studies to explore the phenomenon of gender under-representation have met with the challenges of under-theorization [41]. By drawing on the well-established theory of RCT, this study was designed to explore the decisions of female computer science students, with a view to informing the debate on gender balance in ICT. The questions to emerge from the literature were: for those women on computing courses, what were their early experiences, how did they make the decision to study computing and, finally, who were their influencers.

III. METHODOLOGY

The data was collected through an in-class paper-based survey which collected basic demographic data (gender, age, ethnicity and nationality) then asked three open questions:

(i) Please can you tell us about your first ever experience with computing;

(ii) How you made your decision about which course to study;

(iii) Who did you speak to when deciding which course to study?

The data was collected at a single university over two academic sessions during a class in the second semester of the first year of study (n=185). The paper-based responses were uploaded to Excel for coding. The open comments were grouped into themes using Interpretive Phenomenological Analysis (IPA). The coded data was analyzed in SPSS.

IV. FINDINGS

An initial comparison of responses between the two cohorts was conducted and found no significant differences across the three main questions so the data sets were combined. Table 1 shows the participants by gender across both cohorts. A further 6 (3%) responses were obtained where the gender question was 'prefer not to say' or 'other'. As no further detail was requested these responses have been eliminated.

TABLE I. PARTICIPANTS BY GENDER

	Number of Participants by Gender and Cohort		
	Participant totals	***2017***	***2018***
Male	143 (77%)	99 (79%)	44 (75%)
Female	42 (23%)	27 (21%)	15 (25%)

A. *Early experiences of computing*

Student responses on their first experience of computing were coded into the following categories: home, primary school, secondary school or later. To compare for gender differences in responses, a chi-square test of homogeneity was conducted. An initial test including answers that misunderstood the question as a category resulted in no significant difference $\chi2(3) = 7.02$, p=.071. However, excluding answers that misunderstood the question (interpreting it as their early experiences of computing on their course) resulted in a significant difference in male and female responses, $\chi2(2) = 6.54$, p=.038. Post hoc analysis with a Bonferroni correction showed a significant difference in the proportion of male students that had their first experience of computing at home in comparison to female students (n=70, 57% vs n=12, 34%), p<.01667.

We found that women were introduced to computing with a fairly even distribution across various stages (including home, early schooling and secondary schooling), whereas men were more likely to have been introduced to computers at home (as shown in Figure 1 and Table 2).

TABLE II. EARLY EXPERIENCE OF COMPUTING BY GENDER

	Male	*Female*	*Total*
Home	70 (57.4%)	12 (34.3%)	82 (52.2%)
Primary School	15 (12.3%)	9 (25.7%)	24 (15.3%)
Secondary School or later	37 (30.3%)	14 (40%)	51 (32.5%)

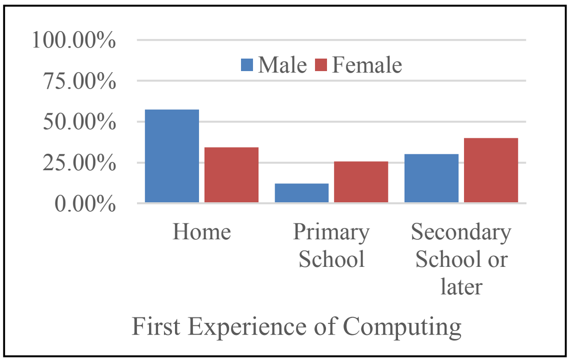

Fig. 1. Early experiences of computing

Early experience varied between male and female respondents. The following are typical responses from the women: "primary school computer club and then taking computing in high school", "my first experience with computing was in high school" and "although I had used computers frequently, my first proper computing experience was in third year where we were set the challenge to make a … game." Echoing studies finding evidence of a playful attitude towards computing, typical male responses included: "When I was about 9 years old my dad let me on his computer he used to work on. I had seen some code which I presume was C that I didn't understand but was curious about" and "I love playing games, so at first I just used them as gaming consoles, until I figured computers can do pretty much anything."

B. *Deciding to study computing*

A chi-square test of homogeneity was conducted to compare gender difference in deciding factors to study computing. The categories were initially sorted into interest, career prospects, family contact, flexibility, experience and other, however, this resulted in having 4 cells having an expected count of 5 and so, some of the answers were recoded into existing categories. Table 3 shows the distribution of male and female responses. There was a significant difference in male and female students' deciding factors to study computing, $\chi2(3) = 7.884$, $p=.049$ (Figure 2). Post-hoc analysis using multiple z-tests with Bonferroni correction showed a significant difference in the proportion of male and female students who took the course based on interest, ($n=77$, 55% vs $n=13$, 33%; $p<.0125$). There was also a significant difference in the proportion of male and female students who took the course with their family as deciding factors, ($n=4$; 3% vs $n=4$, 10%; $p<.0125$).

TABLE III. FACTORS TO STUDY COMPUTING BY GENDER

	Male	*Female*	*Total*
Interest	77 (54.6%)	13 (33.3%)	90 (50%)
Career	24 (17%)	9 (23.1%)	33 (18.3%)
Family	4 (2.8%)	4 (10.3%)	8 (4.4%)
Others	36 (25.5%)	13 (33.3%)	49 (27.2%)

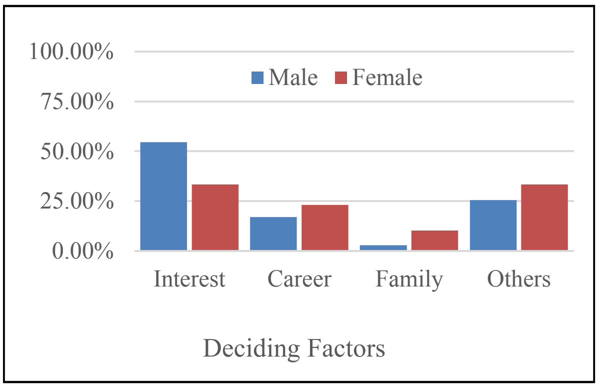

Fig. 2. Reasons to study computing

The female responses to why they had decided to study computing varied across the themes to emerge from the responses, namely: interest in the subject, a good career, and having a family member in the profession. The female responses were distributed more evenly across the themes than the male responses. Interest/ passion for the subject was the most commonly cited reason for both, however men were significantly more likely to select it based on personal interest. Typical male responses included for example, "I've been programming for years, decision was clear and quick" and "I wasn't exactly sure what I wanted to do, but I liked computers, so I chose a general course that would give me the most opportunities."

A focus on the future benefits was cited by many women and evidenced through, for example, "technology is the future and I wanted to be able to gain a job after my degree." Family members were part of the decision-making process for some women, for example "my brother inspired me to do it and I enjoy it so far" and for one, "my mum is in computing and I fancied it because she said it was fun." As elsewhere, when taking the decision to study computing, prior confidence in ability was a factor, for example, one of the female respondents stated that they were "good at IT at school." In this case school was the location of confidence-building rather than home.

C. *Influencers*

Finally, participants were asked who they spoke to in terms of making their decision. A chi-square test of homogeneity was conducted to compare gender difference. Initially, advisers at university open days were coded into a separate category but this was recoded into school advisors to minimize cells having expected count of 5. Table 4 and Figure 3 shows the distribution of male and female responses. There was no significant gender difference in people who influenced students choice, $\chi2(2) = 3.775$, $p=.151$.

TABLE IV. INFLUENCERS BY GENDER

	Male	*Female*	*Total*
Friends and family	68 (50%)	22 (53.7%)	90 (50.8%)
School Advisor	41 (30.1%)	16 (39%)	57 (32.2%)
Nobody	27 (19.9%)	3 (7.3%)	30 (16.9%)

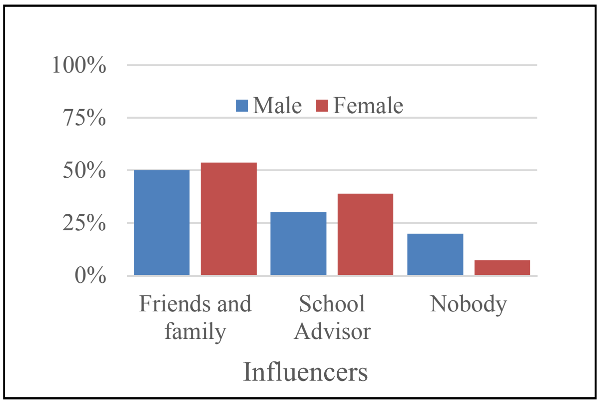

Fig. 3. Who did you speak to about choosing your course?

The following, showing evidence of careful research, is typical of female responses:

"Mainly one of my teachers at school. She knew another student who did my course and really enjoyed it. I then travelled to .. one of the open days and was able to ask questions on the day which was really helpful in my decision of which course of study to take." (Female participant)

Male respondents had spoken to brothers, uncles, parents but also quite typically made the decision entirely by themselves, for example, "I knew that I would study computing from years ago. I didn't need to consider what I would study with anyone" and "I didn't speak with no one. I've decided which course I will study by myself."

V. DISCUSSION

Participants had all enrolled on a computer science major. However, the early experiences and decision reasoning were found to differ between the male and female participants. This discussion section is framed by Rational Choice Theory's proposition of analysis of choice based on reasoned decisions and perceived consequences [42].

A. Action by reasoned decisions

In order to get a sense of the reasoning behind positive reasons for selecting computing, the survey asked in particular why participants had chosen to study computing and who they had spoken to when making their decision to study CS. Furthermore the level of knowledge behind their decision was also observed through asking about early experiences. The female respondents were observed to have many and varied reasons for studying computing, while the men were largely basing their decision on having an interest or passion for the subject. Reasoning for women was slightly more likely to be economic i.e. the prospect of a good career (23%), but this featured less for men (17%). Likewise, Beyer found women to be pragmatists [33], for example, finding that the number of job openings in a field was a factor mentioned in career choices, which corroborates a finding by Zhang [43]. However, Lehman [44] warns about student reliance on instrumental reasons to attend university which can deter students from integrating fully and lead to subsequent feelings of alienation. This is a factor that could be more widely explored in the context of the leaky pipeline. Further evidence of the nature of reasoning by the female participants is the significant difference between female and male participants' responses highlighting the role of family and friends as impacting on their decision-making. Where family might have a less positive view of the tech sector (for example the 'nerdy' image of the profession [45]) the impact of their negative views is likely to have more impact on women making the decision to study CS than men. In fact, more women decide *not* to study computer science than decide *to* study it. If they have access to the same information on careers as our female participants, then such agents are balancing constraints and opportunities differently [39].

For the male respondents, the benefits of being interested in the discipline outweighed future considerations. Interest in a subject increases in situations where an individual believes they belong, and think they have a good chance of being successful [46]. However, some of the male reasoning was questionable, including respondents citing the aim to work for a specific employer.

B. Perceived consequences and the likelihood of success

RCT reasoning includes an assessment of perceived consequences and the likelihood of a choice leading to a successful outcome. The perceived consequences of a successful outcome to their decision to study computing for the women in this study were, in the main, an attractive career. Certainly the Information Technology sector boasts high pay and rewards and is regularly deemed one of the most attractive jobs, based on pay and other factors (for example, [47]).

Participants were not specifically asked about how they perceived their likelihood of success, however, determining a successful career as an outcome can be considered a longer term goal, based on academic success. Female participants' perceptions of success were influenced by interactions with friends and family, locating such reasoning within close social circles, a finding reported elsewhere [48]. Incomplete knowledge of IT careers and influence of negative imagery of the IT profession would thus have greater impact on women's decision-making. Considering the home as a source of acquiring information on which to build a perception of likelihood of success, work extending Eccles' General Expectancy-Value Model of Achievement Choices [49] to consider family responses to studying STEM found boys receiving more support for their interest in math than girls [50]. Indeed Eccles' research has shown that parents tend to slightly overestimate math ability of their son, and underestimate their daughters' math abilities which, in turn, impacts on their daughters decisions regarding studying STEM subjects. Thus, seeking information from parents to inform decision-making might lead to different responses for women and men, and thus different reasoning.

Overall, the female students in this study were observed to be making well-reasoned choices based on speaking to friends and family and having prior knowledge of computing.

C. Limitations

Beyond basic demographic data, the study asked only three questions and coded the responses to find some initial themes. It would be beneficial to conduct in-depth interviews with participants to obtain more nuanced data about the process involved in decision-making, the interventions that impacted reasoning and the interplay of reasoning and perceptions of consequences, including perceived chances of success.

VI. CONCLUSION

Increasing gender balance on computer science courses is proving to be a persistent and ongoing challenge for universities in the US, UK and elsewhere. This study considered the reasons for women making a positive decision to study computer science and compared these with the reasons given by the men in the same cohort. Overall, long term benefits acted in the main as a motivator for selecting CS as a course to study. Many women mentioned a future featuring a good career so careers counselors and industry should be encouraged to do more to promote IT careers to female school pupils. Furthermore school teachers should be aware of the impact of their encouragement (or discouragement) of female pupils as a counter-measure to parental influence. For universities, the challenge is to find ways of stoking interest in CS amongst school pupils and their parents then providing the right environment for women so perceived likelihood of success translates into success. Targeting women returners for upskilling to computing careers would be fruitful for skills gaps and as a means to change parental perceptions. The tech industry would have to welcome such workers. Recent grass roots initiatives celebrating coding for all ages have potential, in the longer term, to lead to a greater understanding and respect of computer science filtering into homes and, crucially, the psyche of parents.

ACKNOWLEDGMENT

The authors would like to acknowledge Gabriele Maffoni's contribution to the data entry and analysis.

VII. REFERENCES

[1] E. Trauth, "What can we learn from gender research? Seven lessons for business research methods.," *The Electronic Journal of Business Research Methods,* vol. 9, no. 1, pp. 1-9, 2011.

[2] Scottish Funding Council, "Gender Action Plan: annual progress report," 2017. [Online]. Available: http://www.sfc.ac.uk/web/FILES/corporatepublications_sfccp042017/SFCCP042017_GAP_annual_progress_report.pdf. [Accessed 15 04 2018].

[3] K. Barg, "Educational choice and cultural capital: examining social stratification within an institutionalized dialogue between family and school," *Sociology,* vol. 49, no. 6, pp. 1113-1132, 2015.

[4] L. J. Sax, K. J. Lehman, J. A. Jacobs, M. A. Kanny, G. Lim, L. Monje-Paulson and H. B. Zimmerman, "Anatomy of an enduring gender gap: The evolution of women's participation in computer science," *The Journal of Higher Education,* vol. 88, no. 2, pp. 258-293, 2017.

[5] A. van Langen, "Girls and STEM choice in Dutch education: the strong gender segregation and the good practice of the Stimulation Policy," *Gender Studies & Research,* vol. 13, 2015.

[6] J. Margolis and A. Fisher, Unlocking the clubhouse: Women in computing, MIT press, 2003.

[7] V. A. Lagesen, "The strength of numbers: Strategies to include women into computer science," *Social Studies of Science,* vol. 37, no. 1, pp. 67-92, 2007.

[8] K. Moore, M. Griffiths, H. Richardson and A. Adam, "Gendered futures? Women, the ICT workplace and stories of the future," *Gender, Work & Organization,* vol. 15, no. 5, pp. 523-542, 2008.

[9] R. Donnelly, D. Grimshaw and M. Miozzo, "Does the UK have a 'comparative institutional advantage'that is supportive of the IT services sector?," *New Technology, Work and Employment,* vol. 26, no. 2, pp. 98-112, 2011.

[10] J. Main and C. Schimpf, "The Underrepresentation of Women in Computing Fields: A Synthesis of Literature Using a Life Course Perspective," *IEEE Transactions on Education,* vol. 60, no. 4, pp. 296-304, 2017.

[11] T. J. Misa, Gender codes: Why women are leaving computing., John Wiley & Sons, 2011.

[12] C. Lang, J. Fisher, A. Craig and H. Forgasz, "Outreach programmes to attract girls into computing: how the best laid plans can sometimes fail," *Computer Science Education,* vol. 25, no. 3, pp. 257-275, 2015.

[13] C. Frieze and J. L. Quesenberry, "From difference to diversity: including women in the changing face of computing," in *Proceeding of the 44th ACM technical symposium on Computer science education*, 2013.

[14] A. Craig, "Theorising about gender and computing interventions through an evaluation framework," *Information Systems Journal,* vol. 26, no. 6, pp. 585-611, 2016.

[15] HESA, "What do HE students study," 2017. [Online]. Available: https://www.hesa.ac.uk/data-and-analysis/students/what-study.

[16] "Attainment Statistics," 5 Dec 2017. [Online]. Available: https://www.sqa.org.uk/sqa/64717.4239.html.

[17] D. R. Baker, "Equity issues in science education," in *Understanding Girls*, Rotterdam, SensePublishers, 2016, pp. 127-160.

[18] J. Hur, C. Andrzejewski and D. Marghitu, "Girls and computer science: experiences, perceptions, and career aspirations," *Computer Science Education,* vol. 27, no. 2, pp. 100-120, 2017.

[19] P. M. Sadler, G. Sonnert, Z. Hazari and R. Tai, "Stability and volatility of STEM career interest in high school: A gender study," *Science Education,* vol. 96, no. 3, pp. 411-427, 2012.

[20] B. Schinzel, "The contingent construction of the relationship between gender and computer science," in *Proceedings 1999 International Symposium on Technology and Society, 1999. Women and Technology: Historical, Societal, and Professional Perspectives.* , 1999.

[21] P. Kinnunen, M. Marttila-Kontio and E. Pesonen, "Getting to know computer science freshmen," in *Proceedings of the 13th Koli Calling International Conference on Computing Education Research*, 2013.

[22] J. J. Jirout and N. S. Newcombe, "Building blocks for developing spatial skills: Evidence from a large, representative US sample," *Psychological science,* vol. 26, no. 3, pp. 302-310, 2015.

[23] G. Nugent, B. Barker, N. Grandgenett and V. I. Adamchuk, "Impact of robotics and geospatial technology interventions on youth STEM learning and attitudes," *Journal of Research on Technology in Education,* vol. 42, no. 4, pp. 391-408, 2010.

[24] A. Master, S. Cheryan, A. Moscatelli and A. N. Meltzoff, "Programming experience promotes higher STEM motivation among first-grade girls," *Journal of experimental child psychology,* vol. 160, pp. 92-106, 2017.

[25] C. M. Lewis, R. E. Anderson and K. Yasuhara, "I Don't Code All Day: Fitting in Computer Science When the Stereotypes Don't Fit," in *Proceedings of the 2016 ACM Conference on International Computing Education Research*, 2016.

[26] S. L. Rodriguez and K. Lehman, "Developing the next generation of diverse computer scientists: the need for enhanced, intersectional computing identity theory," *Computer Science Education,* pp. 1-19, 2018.

[27] G. C. E. Research, "Women who choose computer science–what really matters: The critical role of encouragement and exposure.," 2014. [Online]. Available: http://static. googleusercontent. com/media. [Accessed 26 04 2018].

[28] E. De Lara and L. Y. Liu, "Identification, and the Crucial Role of Key Factors that Affect Women's Interest in Computer Science-A Qualitative Study of Women From Sweden, Mexico and India.," University of Gothenburg, 2016.

[29] G. Stoet and D. C. Geary, "The gender-equality paradox in science, technology, engineering, and mathematics education," *Psychological science,* vol. 0956797617741719, 2018.

[30] S. Marginson, R. Tytler, B. Freeman and K. Roberts, "STEM: country comparisons: international comparisons of science, technology, engineering and mathematics (STEM) education," Australian Council of Learned Academies, 2013.

[31] S. J. Leslie, A. Cimpian, M. Meyer and E. Freeland, "Expectations of brilliance underlie gender distributions across academic disciplines," *Science,* vol. 347, no. 6219, pp. 262-265, 2015.

[32] A. Settle, J. Lalor and T. Steinbach, "Reconsidering the Impact of CS1 on Novice Attitudes," in *Proceedings of the 46th ACM Technical Symposium on Computer Science Education*, 2015.

[33] S. Beyer, "Why are women underrepresented in Computer Science? Gender differences in stereotypes, self-efficacy, values, and interests and predictors of future CS course-taking and grades," *Computer Science Education,* vol. 24, no. 2-3, pp. 153-192, 2014.

[34] K. Kirkpatrick, "Coding as sport," *Communications of the ACM,* vol. 59, no. 5, pp. 32-33, 2016.

[35] L. Beck and A. Chizhik, "Cooperative learning instructional methods for CS1: Design, implementation, and evaluation," *ACM Transactions on Computing Education (TOCE),* vol. 13, no. 3, p. 10, 2013.

[36] P. G. J. &. S. M. Sankar, " An examination of belongingness and confidence among female computer science students.," *ACM SIGCAS Computers and Society,* pp. 45(2), 7-10., 2015.

[37] S. L. Green, "Rational choice theory: An overview," in *A paper prepared for the Baylor University Faculty Development Seminar on Rational Choice Theory*, Waco, TX, Baylor University, 2002.

[38] N. Ramirez, S. Smith, C. Smith, T. Berg, B. Strubel, M. Ohland and J. Main, "From Interest to Decision: A Comparative Exploration of Student Attitudes and Pathways to Co-op Programs in the United States and the United Kingdom," *IJEE,* vol. 32, no. 5, pp. 1867-1878, 2016.

[39] W. J. Goode, "Rational Choice Theory," *The American Sociologist ,* pp. 28(2), 22-41., 1997.

[40] C. Kroneberg and F. Kalter, "Rational choice theory and empirical research: Methodological and theoretical contributions in Europe," *Annual Review of Sociology,* vol. 38, pp. 73-92, 2012.

[41] A. Adam, M. Griffiths, C. Keogh, K. Moore, H. Richardson and A. Tattersall, "Being an 'it'in IT: gendered identities in IT work," *European Journal of Information Systems,* vol. 15, no. 4, pp. 368-378, 2006.

[42] S. L. S. C. &. T. E. A. Foy, "The rise of rational choice theory as a scientific/intellectual movement in sociology.," *The American Sociologist,* pp. 49(1), 16-36., 2018.

[43] W. Zhang, "Why IS: Understanding undergraduate students' intentions to choose an Information Systems major," *Journal of Information Systems Education,* vol. 18, no. 4, p. 447, 2007.

[44] Lehmann, "Working-class students, habitus, and the development of student roles: A Canadian case study," *British Journal of Sociology of Education,* pp. 33(4), 527-546, 2012.

[45] N. L. C. T. C. &. C. L. Anderson, "'Because it's boring, irrelevant and I don't like computers': Why high school girls avoid professionally-oriented ICT subjects.," *Computers & Education,* vol. 50(4), pp. 1304-1318, 2008.

[46] V. Valian, "Interests, gender, and science," *Perspectives on Psychological Science,* vol. 9, no. 2, pp. 225-230, 2014.

[47] CareerCast, "The best jobs of 2017," 2017. [Online]. Available: http://www.careercast.com/jobs-rated/best-jobs-2017.

[48] G. C. E. Research, "Women who choose computer science–what really matters: The critical role of encouragement and exposure.," 2014. [Online]. Available: http://static. googleusercontent. com/media. [Accessed 26 4 2018].

[49] J. Eccles, T. F. Adler, R. Futterman, S. B. Goff, C. M. Kaczala, J. Meece and C. Midgley, "Expectancies, values, and academic behaviors," in *Achievement and achievement motives: Psychological and sociological approaches*, San Francisco, W H Freeman, 1983, pp. 75-146.

[50] J. S. Eccles, "Gendered socialization of STEM interests in the family," *International Journal of Gender, Science and Technology,* vol. 7, no. 2, pp. 116-132, 2015.

[51] R. Boudon, "Beyond rational choice theory," *Annual review of sociology,* vol. 29, no. 1, pp. 1-21, 2003.

[52] R. Breen and J. H. Goldthorpe, "Explaining educational differentials: Towards a formal rational action theory," *Rationality and society,* vol. 9, no. 3, pp. 275-305, 1997.

[53] T. R. Burns, "Two conceptions of human agency: rational choice theory and the social theory of action," in *Agency and Structure (RLE Social Theory): Reorienting Social Theory*, 2014, p. 197.

[54] A. Craig, "Australian interventions for women in computing: are we evaluating?," *Australasian journal of information systems,* vol. 18, no. 2, pp. 91-110, 2014.

[55] I. Heemskerk, A. Brink, M. Volman and G. Ten Dam, "Inclusiveness and ICT in education: a focus on gender, ethnicity and social class," *Journal of Computer Assisted Learning,* vol. 21, no. 1, pp. 1-16, 2005.

[56] R. Wilson, R. Beaven, M. May-Gillings, G. Hay and J. Stevens, "Working futures 2012-2022: evidence report 83," UK Commission for Employment and Skills, Wathe-on-Dearne, 2014.

[57] N. M. Ramirez, J. B. Main, T. L. Fletcher and M. W. Ohland, "Academic predictors of cooperative education participation.," in *Frontiers in Education Conference*, Madrid, 2014.

[58] A. Lishinski, A. Yadav, J. Good and R. Enbody, "Learning to program: Gender differences and interactive effects of students' motivation, goals, and self-efficacy on performance," in *Proceedings of the 2016 ACM Conference on International Computing Education Research (ICER'16)*, 2016.