The OMSCS Gender Gap

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ABSTRACT
In January 2014, Georgia Institute of Technology welcomed the first intake of students to its Online Master of Science in Computer Science (OMSCS) program, a program established with the goal of making high level computer science education more widely accessible. Yet, since then, only 13% of students admitted to the program have been female. In this paper, we investigate the reasons for the lack of women in the OMSCS program and observe that (i) the majority of OMSCS students are drawn from educational backgrounds in heavily male-dominated fields; (ii) female OMSCS students have less confidence in their computing abilities and a lower sense of belonging in computing than males; and (iii) female OMSCS students typically enter the program with less programming and computer science experience than males. Based on these findings, we propose three initiatives for potentially reducing the OMSCS gender gap.

ACM Classification Keywords
K.3.2 Computer and Information Science Education: Computer science education

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Gender issues; Online higher education.

INTRODUCTION
Women represent just 21% of computer graduates in OECD countries (OECD (2015)) and this proportion is only expected to decrease in the future if no action is taken. Computer science is not the only discipline in which large gender disparities exist. However, addressing the computer science gender gap has become a top priority for the governments of many developed countries because it coincides with a period of unprecedented demand for individuals with computer science skills in these countries. Supply of computer science graduates is failing to meet demand, and the continuation of this problem will likely have serious economic consequences (Deloitte Access Economics (2016), Duncan (2017)). The most effective way to address this problem is to attract members of demographic groups that have historically been underrepresented in computer science into this profession, such as women (Accenture (2016)). As a result, extensive research has been done in recent years regarding the cause of the computer science gender gap and possible ways to reduce it.

The problem of attracting more women into computer science is typically broken down into three sub-problems, each of which deals with attracting women into computer science at different stages of their lives: in their school years; as college undergraduates; and in later life. Much of the research that has been conducted in the field of women in computer science has focused on women in the first two groups (for example, Klawe (2013) and Zagami et al. (2016)). However, attracting women to computer science in later life is just as important, since, in addition to the contribution they can make in this field, they are also well placed to become role models and mentors to the generation that follows. This will, in turn, help increase the number of females going into computer science at the earlier life stages, since girls who are encouraged by a role model are more than four times more likely to major in computer science than those who are not (Accenture (2016)).

With regard to women going into computer science in later life, "more than half (58%) of women (currently) working in computing who went to college did not major in computing as undergraduates" (Accenture (2016)). Therefore, just because a woman did not specialize in computing during their undergraduate studies, does not necessarily mean that she is lost to this profession for life. As many women in this group are at a stage of life where, due to work or family commitments, on-campus classes are not a viable option, one way these women can gain the skills they need in order to transition into a career in computer science is through online degree programs and Massive Open Online Courses (MOOCs). Online degree programs are, in fact, typically very popular among women, with females making up around 70% of online undergraduate students and 72% of online graduate students (Haynie (2015)). Nevertheless, in spite of this, women are poorly represented in online computer science programs. For example, women comprise just 20% of enrollments in Coursera's computer science, engineering and mathematics MOOCs (Paul (2014)) and 13% of enrollments in Georgia Institute of Technology's (Georgia Tech's) Online Master of Science in Computer Science (OMSCS) program (Georgia Tech (2016)).

Georgia Tech's OMSCS program is a part time, online-only Master's program that commenced in January 2014. It now enrolls over 4,000 students, while maintaining a total degree cost of around US$7,000 (Carey (2016)), less than one-sixth the cost of Georgia Tech's equivalent on-campus Master of Science in Computer Science degree. The OMSCS program was established with the goal of making "high-level advanced education in computer science accessible to a much larger body of students" (Georgia Tech (2016)) and is now "the largest computer science Master's degree program in the United States, and possibly the world" (Goodman et al. (2016)). Yet, in spite of this program succeeding in improving access to advanced computer science education for those from lower income backgrounds and traditionally under-represented racial minority groups, the program has had little impact on the computer science gender gap, with females representing an even lower proportion of OMSCS applicants than applicants to Georgia Tech's equivalent on-campus program (Goodman et al. (2016)).

The aim of this paper is to uncover the reasons for the lack of female participation in the OMSCS program. Through the analysis of survey and grade data, we investigate differences that exist between female OMSCS students and their male counterparts, focusing in particular on differences in: (i) demographics; (ii) academic performance and behavior; (iii) pre-OMSCS computing experience; (iv) self-confidence; and (v) sense of belonging in OMSCS and computer culture in general. Determining whether any gender differences exist with regard to the last three areas listed above is considered to be of particular relevance, since previous research into the reasons for the lack of women in computer science, in general, has identified a low sense of belonging in computer culture; lack of sufficient early experience in computing; and a lack of self-confidence in computing skills as being the three main reasons for the gender gap that exists in computer science (Klawe (2013), Cheryan et al. (2017)).

Consistent with the above mentioned prior research, our analysis shows that, although female OMSCS students are more likely to have an advanced degree, and perform just as well, academically, as their male counterparts, they have significantly less confidence in their ability to succeed in OMSCS and have a weaker sense of belonging in OMSCS and computer science in general. It also shows that female OMSCS students typically enter the program with less programming experience and computer science work experience than their male counterparts, and are less likely to have previously studied computer science at a college level. Based on these findings, we propose several initiatives that could be used to increase female participation in the OMSCS, which are also potentially transferable to other advanced level computer science degree programs.

DATA

Students enrolled in the OMSCS versions of three classes: Knowledge-Based Artificial Intelligence (KBAI; Summer 2015 and Summer 2016), Educational Technology (EduTech; Fall 2015, Spring 2016 and Fall 2016) and Human-Computer Interaction (HCI; Fall 2016)[1], were administered a series of four surveys, conducted at set points throughout the semester (the beginning, quarter-way, middle and end of semester). Surveys were administered online, by the instructor (the same instructor for all three classes), and in total, 1,004 sets of survey results (observations) were collected, representing a total of 854 unique students[2] (123 females, 715 males and 16 unknown). A breakdown of the number of observations by class, semester and gender is presented in Table 1.

Course Offering	Females	Males	Unknown	Total
KBAI				
Summer 2015	39	244	4	287
Summer 2016	37	257	5	299
EduTech				
Fall 2015	17	72	5	94
Spring 2016	12	105	0	117
Fall 2016	25	95	4	124
EduTech				
Fall 2016	20	60	3	83

Table 1. Number of observations in the course survey data by class, semester and gender

Grade data was merged with the survey data for all classes and all semesters, with the exception of the Fall 2015 offering of EduTech. Although grade data was available for this offering of this class, the marking scheme used was such that it did not readily translate into a single numeric grade, suitable for quantitative comparison. As a result, the grades for this course offering were excluded from the analysis.

As the course survey data provided only limited information about students' pre-OMSCS computing experiences and levels of self-confidence, and no information on students' sense of belonging in the OMSCS program, an additional survey was also run, by the author, to collect this data. The survey, of self-selected, past and present OMSCS students, was conducted online between March 23, 2017 and April 14, 2017, and is referred to throughout this paper as the "supplementary survey". Responses were anonymous and it was not possible to link them to the course survey data. In total, 160 responses were received, from 57 females and 103 males.

METHODOLOGY

Welch's t-test has been used throughout this analysis in order to determine the significance of any differences in quantitative characteristics between male and female OMSCS students. In all cases, the sample means compared as part of this test (i.e. the means by gender of the characteristic under consideration), as well as the p-values for the test, are reported. In each case, the (nonparametric) Mann-Whitney U test was also run, to confirm that any deviations from normality were not distorting the results. However, the Mann-Whitney U test and Welch's t-test were found to produce consistent results, so the p-values for the Mann-Whitney U test are not reported.

To determine if gender is significant in determining the quantitative characteristics under consideration in the presence of other independent variables, regression analysis has been used. In each case, a regression model has been fit to the dependent variable under consideration, with the following independent variables used, depending on the data set:

- **Course Survey Data:** an indicator for whether a student is male (the gender indicator); age; an indicator for whether a student is a native English speaker (the native speaker indicator); an indicator for whether a student has completed

[1] KBAI and HCI are traditional, lecture-based classes, while EduTech is a research-based class.

[2] Students enrolled in more than one of the listed classes were administered the series of surveys once for each class they were enrolled in, resulting in some students being represented more than once in the data.

an advanced degree[3] (the advanced degree indicator); and semester; and

- **Supplementary Survey Data:** the gender indicator; age; the native speaker indicator; the advanced degree indicator; and number of courses completed to date.

The fitted value of the coefficient of the gender indicator, and the p-value for the t-test that the coefficient of the gender indicator is equal to zero, are also reported.

A 5% significance level is assumed throughout this paper.

RESULTS

Demographic Variables

Table 2 compares several key demographic variables by gender for the course survey data.

Variable	Females	Males
Average Age	33.6	32.8
Place of Birth		
USA	45.5%	57.3%
China	19.5%	7.7%
India	13.0%	9.9%
Other Asia	8.1%	9.9%
Europe	4.9%	4.2%
Rest of World	9.0%	11.0%
% currently resident in USA	90.2%	88.0%
% native English speakers	53.7%	67.9%
Highest Prior Ed. Level		
High School	0.0%	0.3%
Bachelor's	65.0%	75.4%
Master's	20.3%	19.4%
Doctoral	14.6%	4.9%

Table 2. Demographic variables by gender, based on the course survey data

Although male and female OMSCS students are demographically similar with regard to age and country of residence, female students are 21% less likely to be born in the USA (and 48% more likely to be born in Asia) than their male counterparts, and 44% more likely to have previously obtained an advanced degree.

Other than the highest level of educational attainment, the course survey data provides little insight into the educational backgrounds of OMSCS students. Nevertheless, based on the supplementary survey data, as shown in Table 3, both male and female OMSCS students are most likely to have attained their highest prior educational qualification in computer science or engineering, with 70% of females and 81% of males attaining their highest prior qualification in one of these two fields.

Academic Performance and Behavior

Academic performance and behavior was evaluated in terms of two variables: average grades and average time spent studying per week. Both of these variables are represented in both of the data sets under consideration. In the case of the course survey data, the variables were considered by class, to allow for any differences that may exist between the workloads and difficulty levels of the different classes.

[3]An advanced degree is defined as a Master's or Doctoral degree.

Field of Highest Prior Ed.	Females	Males
Computer Science	40.4%	48.5%
Engineering	29.8%	32.0%
Mathematics/Statistics	14.0%	3.9%
Other Science	8.8%	8.7%
Humanities/Arts	5.3%	2.9%
Other	1.7%	4.0%

Table 3. Field of highest prior educational attainment, based on the supplementary survey data

Table 4 shows the average number of study hours per week (for the class under consideration only) and average (final) course grade by class and gender, based on the course survey data, while Table 5 shows the average number of study hours per week (for all OMSCS classes) and average grade point average (GPA) (out of four) by gender, based on the supplementary survey data.

	Welch's t-test			Regression	
Variable	*Females*	*Males*	*p-val.*	*Coef.*	*p-val.*
Ave Study Hrs/Wk					
KBAI	14.4	13.4	0.12	-0.609	0.38
EduTech	12.3	11.5	0.29	-0.739	0.41
HCI	9.0	9.2	0.90	-0.048	0.96
Ave Course Grade					
KBAI	79.8%	78.1%	0.22	-1.371	0.25
EduTech	87.2%	88.4%	0.25	-0.417	0.73
HCI	82.9%	83.5%	0.68	-1.502	0.27

Table 4. Academic performance and behavior measures by gender, based on the course survey data

	Welch's t-test			Regression	
Variable	*Females*	*Males*	*p-val.*	*Coef.*	*p-val.*
Ave Study Hrs/Wk	21.0	19.7	0.38	-1.713	0.28
Ave GPA to Date	3.77	3.72	0.32	-0.054	0.31

Table 5. Academic performance and behavior measures by gender, based on the supplementary survey data

Based on these tables, there is no evidence to suggest that any significant differences exist between male and female OMSCS students with regard to academic performance or time devoted to studying.

Pre-OMSCS Computing Experience

Three measures of pre-OMSCS computer science experience were collected as part of the supplementary survey: whether or not a respondent had previously completed a college-level computer science course prior to commencing the OMSCS program; number of years of pre-OMSCS computer programming experience (in any programming language); and number of years of pre-OMSCS work experience in roles that required advanced computing skills. These measures are summarized by gender in Table 6.

Based on this table, it can be seen that female OMSCS students are 32% less likely to have previously studied computer science at a college level and have significantly less pre-OMSCS programming and computer science related work experience than their male counterparts. Even after allowing for

Variable	Welch's t-test *Females*	*Males*	*p-val.*	Regression *Coef.*	*p-val.*
% completed prior CS course	49.1%	71.8%	0.01*	0.987	0.01*
Ave Prior Programming Exp. (Yrs)	6.19	9.38	0.00*	2.040	0.02*
Ave Prior CS Work Exp. (Yrs)	4.21	6.67	0.00*	1.490	0.04*

* indicates significance at the 5% significance level

Table 6. Pre-OMSCS computer science (CS) and programming experience measures, based on the supplementary survey data

such factors as age and prior completion of an advanced degree, gender was still found to be signficant in predicting each of these measures.

Self-Confidence and Sense of Belonging

In each of the course surveys administered to KBAI, EduTech and HCI students, with the exception of the beginning of class survey, students were asked to rate their level of confidence (out of five) in how well they had performed in the class to date and how well they expected to perform in the class in future (this second question was omitted from the end of course survey, for obvious reasons). In total, three prior performance confidence ratings and three future performance confidence ratings were collected per student per class, which were averaged and summarized in Table 7. Averages are reported at a class level to allow for differences in the difficulty levels of the different classes.

Variable	Welch's t-test *Females*	*Males*	*p-val.*	Regression *Coef.*	*p-val.*
Ave Conf. in Prior Perf.					
KBAI	3.50	3.57	0.57	0.061	0.62
EduTech	3.98	4.24	0.01*	0.293	0.03*
HCI	3.93	4.39	0.04*	0.195	0.44
Ave Conf. in Future Perf.					
KBAI	3.75	3.76	0.92	0.059	0.62
EduTech	3.91	4.14	0.07	0.232	0.11
HCI	4.33	4.25	0.57	-0.100	0.61

* indicates significance at the 5% significance level

Table 7. Confidence in past and future performance by class, based on the course survey data

In all but one case, male students were found to be, on average, more confident than female students. However, with the exception of confidence levels regarding prior performance in EduTech and HCI, confidence levels do not differ significantly by gender.

Allowing for other variables via regression analysis, the majority of the above results continue to hold true, although gender ceases to be significant in predicting confidence in prior performance in HCI.

In the supplementary survey, students were asked to rate their levels of confidence in succeeding in the OMSCS program (out of five) both prior to commencing and at the time of taking the survey. The averages of these ratings, by gender, are shown in Table 8.

Again, in all cases, male students are, on average, more confident than female, but this time, the difference is statistically significant. This result continues to hold, even after allowing for other factors via regression analysis, in the case of confidence prior to commencing, but ceases to be significant, in the case of current confidence levels.

Variable	Welch's t-test *Females*	*Males*	*p-val.*	Regression *Coef.*	*p-val.*
Ave Conf. in Succeeding in OMSCS					
Prior to Commencing	3.32	4.14	0.00*	0.666	0.00*
Currently	4.18	4.48	0.04*	0.257	0.06
Ave Self-Conf. Score	3.85	4.21	0.00*	0.286	0.01*
Ave Gender Eq. Score	4.52	4.35	0.08	-0.203	0.04*
Ave Belonging Score	3.59	4.00	0.00*	0.425	0.00*

* indicates significance at the 5% significance level

Table 8. Confidence and belonging measures, based on the supplementary survey data

Supplementary survey respondents were also asked to rate their level of agreement (out of five) with a number of statements relating to self-confidence, gender equality and sense of belonging in OMSCS and computing. These ratings were then averaged by category (with negative statements reverse coded prior to averaging) to form three "scores" (a "self-confidence" score, a "gender equality" score and a "belonging" score, respectively). These scores are summarized by gender in Table 8. Cronbach's standardized alpha was used to confirm the consistency of the statements that make up each score, and the resulting calculated values all fell in the range 0.84 to 0.87, indicating an acceptable level of consistency.

With regard to statements relating to self-confidence and sense of belonging in OMSCS/computing, females rated these statements significantly lower, on average, with gender remaining a significant factor in determining the self-confidence and belonging scores even in the presence of other variables. By contrast, in the case of statements relating to gender equality, females rated these statements higher than males, and although the difference between average male and female gender equality scores was not found to be statistically significant, based on Welch's t-test, after allowing for other variables via regression analysis, gender was found to be statistically significant in determining the gender equality score.

In light of the findings in Section , it is of interest to note that the statement "I have a lot of self-confidence when it comes to programming" achieved one of the most statistically significant differences in average rating by gender, with females rating their level of agreement with this statement as 3.28, on average, compared to 4.16 for males (Welch's t-test p-value = 0.00). Therefore, it appears that, at least in part, female students' lower levels of confidence in their computing abilities may stem from their lower levels of programming and computer science experience. Nevertheless, there is no evidence to suggest that either male or female OMSCS students consider female students to be inferior programmers, with the statement "females are just as good as males at programming" receiving an average agreement rating of 4.65 from females and 4.45 from males (Welch's t-test p-value = 0.08).

DISCUSSION

In our analysis, we investigated a range of different variables with the potential to negatively impact the number of women in OMSCS, to see how they differed by gender. Interestingly, however, it is a similarity between males and females, rather than a difference, that is likely to be one of the biggest causes of the gender gap that exists among OMSCS students. Both male and female OMSCS students are most likely to come from an educational background in computer science or engineering. Given the subject matter of the OMSCS program, this is not surprising. Nevertheless, computer science and engineering are two of the most gender imbalanced of all educational disciplines. In OECD countries, women make up just 24% of all engineering graduates, which is only marginally better than the 21% of computing graduates that women represent (OECD (2015)). If the OMSCS is predominantly drawing its students from a pool of individuals that is composed of 75% to 80% males, then it is inevitable that the majority of students admitted to the program will also be male.

Of the students who are admitted to the OMSCS program, the females are more likely to have previously earned an advanced degree and perform just as well, academically, as their male counterparts. Yet, in spite of this, there is evidence to suggest that female OMSCS students have less confidence in their own computing abilities, particularly with regard to programming, and have a lower sense of belonging in OMSCS and computing in general, than males. One possible explanation for this is that female OMSCS students typically enter the program with less programming experience and computer science work experience, and are less likely to have previously studied computer science at college level than males. The lower sense of belonging in computer science/OMSCS is also, potentially, a consequence of the low female representation, not only in the OMSCS student body, but also on the OMSCS faculty, with only two of the 27 classes run in Spring 2017 having a female instructor. Visible female role models are almost completely absent from the OMSCS program.

The lower levels of self-confidence in computing skills, lower sense of belonging in computer culture and lower exposure to computing experiences observed among female OMSCS students, relative to their male counterparts, are consistent with previous findings regarding the reasons for the lack of female participation in computer science (Cheryan et al. (2017)). Assuming that female OMSCS students are likely to have greater self-confidence and sense of belonging in computer science than suitably qualified females who have not applied for the OMSCS program, since an individual must have at least some minimum level of confidence in their computing abilities and sense of belonging in computing in order to apply for admission to a computer science Master's program in the first place, this suggests that these factors may also be contributing to the lack of females in OMSCS.

Klawe (2013) argued that "every CS department that has made a serious and sustained commitment to increasing female participation – starting in the mid-1990s with Carnegie Mellon University and the University of British Columbia – has had substantial success." If Georgia Tech is serious about wanting to use the OMSCS program as a means of making computer science education more widely available, then it is incumbent upon it to make a serious and sustained commitment to attracting suitably qualified women to OMSCS and increasing female participation in this program.

Based on our analysis, three initiatives that could potentially boost female participation in OMSCS include:

1. **Broadening the pool of potential female OMSCS applicants.**

   This could be done by actively targeting individuals from educational backgrounds other than computer science and engineering to join OMSCS. The admission criteria for OMSCS states that the "preferred qualifications for admitted OMSCS students are an undergraduate degree in computer science *or (a) related field* (typically mathematics, computer engineering or electrical engineering) ..." (Georgia Tech (2017)). In OECD countries, females comprise 44% of all mathematics and statistics graduates and 44% of physical sciences graduates (OECD (2015)), more than double the proportion of female computer science and engineering graduates. Actively marketing OMSCS to females from fields related to computer science, but with a higher proportion of females, such as mathematics/statistics and the physical sciences, would not compromise the current OMSCS admissions standards, and would potentially result in an greater numbers of females being reached by any OMSCS marketing campaigns.

2. **Providing opportunities for students to build confidence in their computer science and programming abilities.**

   Ideally, such opportunities should be offered early in the program or immediately prior to commencement and could take the form of preparatory courses extended to students who have either recently been admitted to the program or who are considering applying, or even the form of a "Micro Master's" program, successful completion of which could guarantee entry into the OMSCS. Providing avenues for students with little or no programming experience to participate in computer science has been successfully used to address computer science confidence issues experienced among females at Harvey Mudd College (Klawe (2013)), contributing to a dramatic rise in the proportion of female computer science majors at this college, with women now representing 55% of undergraduate computer science majors (Staley (2016)).

3. **Building a sense of belonging for females in computer science, through creating visible role models for female OMSCS students.**

   This could potentially take the form of increasing the number of female course instructors and presenters in the course lecture videos; making opportunities available for female students to interact with female Georgia Tech computer science researchers; or through creating mentoring opportunities for female students. Providing networking and mentoring opportunities has also been successfully used at the University of Virginia as part of their efforts to boost female computer science participation (Cohoon et al. (2013)).

Future research could potentially involve implementing one or more of these initiatives and determining the impact on the OMSCS gender gap.

CONCLUSION

Since the mid-1980's, the proportion of women undertaking computer science degrees has plummeted (NCWIT (2014)). As the largest computer science Master's program in the US, Georgia Tech's OMSCS program has the potential to help reverse this trend, but to date, Georgia Tech has admitted an even lower proportion of female students to the OMSCS program than to its equivalent, on-campus, Master of Science in Computer Science program. The experience of other universities has shown that, through "serious and sustained commitment," it is possible to significantly boost female participation in computer science, and in this paper, we have proposed three initiatives Georgia Tech could implement to do just that. In is estimated that the OMSCS program has the potential to increase the number of computer science Master's degree holders in the US by up to 8% (Goodman et al. (2016)). Imagine the impact on the computer science gender gap if half of those were women.

References

Accenture (2016). Cracking the Gender Code. https://www.accenture.com/us-en/cracking-the-gender-code?src=JB-11540. Accessed: 25 January 2017.

Carey, K. (2016). An Online Education Breakthrough? A Master's Degree for a Mere $7,000. https://www.nytimes.com/2016/09/29/upshot/an-online-education-breakthrough-a-masters-degree-for-a-mere-7000.html?_r=0. Posted: 28 September 2016.

Cheryan, S., Ziegler, S., Montoya, A., and Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin*, 143(1):1–35.

Cohoon, J., Cohoon, J., and Soffa, M. (2013). Educating diverse computing science students at the University of Virginia. *Computer*, 46(3):52–55.

Deloitte Access Economics (2016). AustraliaâĂŹs Digital Pulse: Developing the digital workforce to drive growth in the future. https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-digital-pulse-2016-acs-110316.pdf. Accessed: 25 January 2017.

Duncan, A. (2017). Educational Equality and Excellence Will Drive a Stronger Economy. https://www.brookings.edu/blog/brown-center-chalkboard/2017/03/02/educational-equality-and-excellence-will-drive-a-stronger-economy/?utm_medium=social&utm_source=twitter&utm_campaign=gs. Posted: 2 March 2017.

Georgia Tech (2016). 2016 OMS Report. www.cc.gatech.edu/2016-oms-report. Accessed: 14 January 2017.

Georgia Tech (2017). Online Master of Science in Computer Science (OMS CS) Admission Criteria. https://www.omscs.gatech.edu/program-info/admission-criteria. Accessed: 21 April 2017.

Goodman, J., Melkers, J., and Pallais, A. (2016). Can Online Delivery Increase Access to Education? Working paper, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts.

Haynie, D. (2015). Why Women Dominate in Online Programs. http://www.usnews.com/education/online-education/articles/2015/08/05/why-women-are-drawn-to-online-learning-in-higher-numbers-than-men. Posted: 5 August 2015.

Klawe, M. (2013). Increasing female participation in computing: The Harvey Mudd College Story. *Computer*, 46(3):56–58.

NCWIT (2014). Women and Information Technology by the Numbers. http://www.ncwit.org/sites/default/files/resources/btn_02282014web.pdf. Accessed: 14 January 2017.

OECD (2015). Share of Women Graduates by Field of Education. https://www.oecd.org/gender/data/shareofwomengraduatesbyfieldofeducation.htm. Accessed: 18 February 2017.

Paul, A. (2014). The MOOC Gender Gap. http://www.slate.com/articles/technology/future_tense/2014/09/mooc_gender_gap_how_to_get_more_women_into_online_stem_classes.html. Posted: 10 September 2014.

Staley, O. (2016). Harvey Mudd College Took on Gender Bias and Now More than Half its Computer-Science Majors are Women. https://qz.com/730290/. Posted: 22 August 2016.

Zagami, J., Boden, M., Keane, T., Moreton, B., and Schulz, K. (2016). Female Participation in School Computing: Reversing the Trend. http://acce.edu.au/sites/acce.edu.au/files/Female-Participation.pdf. Accessed: 15 April 2017.