

Towards Gender Equality in Software Engineering: The NSA Approach

Hélène de Ribaupierre

Cardiff University, School of Computer Science and
Informatics
Cardiff, United Kingdom
deribaupierreH@cardiff.ac.uk

Fernando Loizides

Cardiff University, School of Computer Science and
Informatics
Cardiff, United Kingdom
loizidesF@cardiff.ac.uk

Kathryn Jones

Cardiff University, School of Computer Science and
Informatics
Cardiff, United Kingdom
JonesK90@cardiff.ac.uk

Yulia Cherdantseva

Cardiff University, School of Computer Science and
Informatics
Cardiff, United Kingdom
CherdantsevaYV@cardiff.ac.uk

ABSTRACT

Multiple studies show that women are under-represented in almost all of fields of Science, Technology, Engineering and Maths (STEM). This gender gap is also present at higher education institutions in both student numbers and academic staff. A range of measures could be implemented to tackle this issue. In this position paper, we outline the measures that the School of Computer Science and Informatics of Cardiff University, UK, implemented over the past years, to foster a culture in which women could excel. Then, we discuss the measures that we plan to implement in future in order to increase the number of women both among students and academic staff.

CCS CONCEPTS

• **Social and professional topics** → **Computing education**; *Information systems education*; *Software engineering education*;

KEYWORDS

Gender, Equality, Education, Software Engineering, Computer Science, STEM

ACM Reference Format:

Hélène de Ribaupierre, Kathryn Jones, Fernando Loizides, and Yulia Cherdantseva. 2018. Towards Gender Equality in Software Engineering: The NSA Approach. In *GE'18: GE'18:IEEE/ACM 1st International Workshop on Gender Equality in Software Engineering*, May 28, 2018, Gothenburg, Sweden. ACM, New York, NY, USA, Article 4, 4 pages. <https://doi.org/10.1145/3195570.3195579>

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

GE'18, May 28, 2018, Gothenburg, Sweden

© 2018 Copyright held by the owner/author(s). Publication rights licensed to the Association for Computing Machinery.

ACM ISBN 978-1-4503-5738-8/18/05...\$15.00

<https://doi.org/10.1145/3195570.3195579>

1 INTRODUCTION

Definition. In this paper, when we refer to the term gender equality, we use the definition provided by UNESCO: “Gender equality exists when women and men enjoy the same status and have equal conditions, treatment, and opportunities for realizing their full potential, human rights and for contributing to and benefiting from economic, social, cultural and political development.”[17].

Multiple studies show that women are underrepresented in almost all fields of Science, Technology, Engineering and Maths (STEM) [8, 15]. In particular, in the UK, women represent only 17% of the workforce in ICT [2] and only 14% of the student cohort for undergraduate Computer Science programmes [1]. Why should software engineers, working either in industry or in academia, care about the gender equality in ICT, and what could they do to decrease the imbalance in the participation of women? The most obvious and simple answer is because equality and diversity should be a goal in every aspect of society and this provides a strong motivation to investigate why this shortage of women exists. Another answer could be that it's fashionable, especially after the polemic of 2017 when a software engineer wrote a "manifesto" that argues that biological causes could provide a reason why woman are underrepresented in technology and leadership positions [9]. Another good reason could be economical, as work related to ICT is increasing all over the world, a rise in the number of woman working or being educated in ICT could prevent a shortage of workers in ICT. By bringing a more diverse and equal workforce, workplaces, organisations and industries could increase the critical mass of talents, thoughts and innovative ideas, which will create a snow ball effect and help organisations and industries to reach their full potential. In 2013, Broughton [7] predicated that between 2013 and 2020 the demand for new workers in ICT sectors in the UK alone will be approximately 128,000 qualified individuals each year. The number of graduates, in the UK, by that year in ICT is projected to be 87,000 (65,000 men for 22,000 women) leaving a shortfall of 41,000 graduates per year. All these could still be very strong motivators to increase the percentage of woman studying in ICT fields.

Using the National Software Academy (NSA) at Cardiff University as a case study, we share our knowledge and experience on actions that may help to foster a culture in which women could

excel in the domain of computer science and software engineering. Ultimately we hope this will help raise the number of woman studying and working in this field.

2 CARDIFF UNIVERSITY AND THE NATIONAL SOFTWARE ACADEMY

The School of Computer Science & Informatics at Cardiff University (CU) in the UK offers a number of undergraduate and postgraduate degree programmes. The School is home to approximately 600 undergraduate, 150 postgraduate students and 45 academic staff, with the majority of students on a variant of the BSc Computer Science programme.

Working in close partnership with the Welsh Assembly Government and industry, the School launched the NSA in 2015 to address the national shortage of graduates with software engineering and programming skills. The core ethos of the NSA is “learning by doing” in order to deliver “work-ready” graduates who are able to slot seamlessly into software development teams in industry. The NSA delivers the innovative BSc Applied Software Engineering (ASE) degree with a focus on knowledge, practical skills and hands-on experience required to be immediately effective as a commercial software engineers. The BSc ASE is taught over three years. The first cohort of professional software engineers is due to graduate at the end of the 2017/2018 academic year.

As well as introducing a new degree programme from scratch, the NSA has also involved significant staff recruitment (only the Programme Director, Dr Wendy Ivins, was an existing member of the School) and is due to move into a newly renovated premises in the city of Newport (around 15 miles from the main university in Cardiff).

In this paper, while outlining the school-wide measures, we concentrate more specifically on the experience of moving towards gender equality we have experienced over the past three years the NSA.

2.1 Gender balance among staff

In terms of the number of women among the academic staff, Cardiff University with 26% of women is above the national average of 21% [14]. At the NSA, 55% of academic staff are women (6 women, 5 men). The majority of the teaching staff hired in the last two years to deliver the ASE programme were women and they were hired without any form of quota or positive discrimination. In this section, we describe some of the features that we believe have led to this positive balance.

Recruitment process. The School has implemented a number of changes in its recruitment process resulting from an Athena Swan¹ application, for which the school received a Bronze Award in 2015. Adverts are carefully screened for language associated with gender bias [13]. The opportunities for flexible working, part-time working and a commitment to gender equality are strongly emphasised in all job adverts (this was one of the main aspects that encouraged several authors of this paper to apply for their current positions). All shortlisted candidates are asked to give a presentation as part of the interview process. The guidance for these has been modified to

¹<https://www.ecu.ac.uk/equality-charters/athena-swan/>

Table 1: Percentage of women studying a first degree in Computer Science (CS) and Applied Software Engineering (ASE) at Cardiff University

	2015-2016	2016-2017	2017-2018
CS	15%	17%	19%
ASE	16%	19%	14%

emphasise research quality rather than quantity (e.g. *describe your most significant output rather than simply describe your research*) and instructs candidates to spend equal time on both teaching and research/scholarship. The NSA is also unusual in the way it strongly encourages applications from industry – 3 out of 10 recruits were previously employed in commercial software development.

Novelty and flexibility. As the degree offered by the NSA is a new programme, the teaching style and the teaching staff have some flexibility to introduce new techniques and measures more easily than an already established degree programme. We believe that the challenge of developing the style of delivery and syllabus from scratch, without any existing constraints or the need to conform to traditional stereotypes of an academic environment, have also played a part in attracting staff. This is supported by the physical environment – the NSA has no standard banked lecture theatres, but instead all teaching is delivered in a learning space designed to mimic the environment of commercial software development companies.

The key features of the ASE degree are extensive engagement with industry throughout the degree, a focus on client-lead and client-facing projects, teamwork and exposure to industry working practices. We introduce these features to the students through team software development projects inspired by industry clients (3-4 students per team) following Agile Project Management methodology. These projects run between weeks 5 and 12, with students having at least one client project per year.

2.2 Gender balance among students

We present the figures for the percentage of women studying Computer Science (including all degrees) and the Applied Software Engineering (NSA) (Table 1).

Cardiff University is very close to the national average for women studying an undergraduate degree in Computer Science, and in the last two years, the number of women has increased. However, the number enrolled on the ASE programme has dropped in the last year from 19% to 14%. More investigation will be needed to understand the reasons behind this drop.

Clearly gender balance is not as equal among students as for staff, some measures are already in place to encourage more diversity and equality in the cohort of students. However, we don't yet have an indicator of the success of these measures.

Admissions. The range of measures that we implemented at the NSA start from the early stages of admissions process. During the interview process we emphasise that the BSc ASE degree does not require any previous programming knowledge, as a previous study

shows that girls have less experience with computers than boys [12].

Despite the fact that the degree does not require previous knowledge of programming, some students have either already studied at secondary school or self-studied some programming languages. In the future, we want to investigate the percentage of women and men that have previous knowledge of programming in the first year cohort. We also want to investigate if starting with a different level of computing literacy makes a difference at the end of the three year degree programme. Further to this we could investigate the students' level of computing literacy, between the different Computer Science degrees. It could be part of wider interviews and surveys run with students that would also investigate what motivated them to choose a Computer Science degree, and if men have different criteria than women when they choose their field of study.

Unconscious Bias and Code of Conduct. One measure taken by the College of Physical Sciences and Engineering at Cardiff University is the introduction of a mandatory module about unconscious bias and stereotype threat for every member of the staff. This was again part of the measures for the Athena Swan bronze award of 2015. This module could become mandatory for every student or it could be incorporated into a teaching module. It could complement the introduction of a Code of Conduct for team projects for first year students. We introduced a Code of Conduct this year for the projects: at every level, which includes notions such as inclusion, professionalism and respect.

Conduct their academic work as part of the project without discrimination on the grounds of sex, sexual orientation, age or disability, nationality or race, or of any other condition or requirement;
Promote diversity, creativity and inclusive discussion of all group matters;

Build a student team. The student teams at the NSA are selected by the semester teaching team based on the level of skills which are measured by the average mark from the previous semester. We ensure that every team has equal overall average score, and that the members of each team have skills and abilities that complement each other. We also look at the level of engagement of each student. In addition, we also aim to build diverse teams which include equal numbers of men and women students since research on gender composition indicates that mixed groups exhibit better performance than all-men groups [11]. Existing research also confirms that the presence of women in the group significantly improves collaboration [4], which is crucial in any software development project. We allocate, when it is possible, an equal number of women and men in a same team to avoid possible discrimination behaviour based on the sex.

Role models. Even if studies show conflicting results on the impact of role models for women or men in their studies [5], we advocate in favour of having a good ratio of women and men on the teaching team. We also advocate in favour of a good ratio of women/men by sub-area of software engineering and computer science. Since 2017, for the ASE degree, the ratio of women/men lecturers is balanced. The ratio of women/men lecturers by teaching

Table 2: Number of modules taught by women and men by module type

	Soft skills modules	Technical modules
Women	3	6
Men	4	5

sub-area is also very good (Table 2). We would like to investigate if the representation of women/men teachers in sub-area could have an impact on the future specialisation of students.

Assessment marking schemes. Multiple-choice question (MCQ) tests are used for assessment at the NSA in several modules. We pay attention to the design of MCQ tests with the aim of avoiding gender bias. Previous studies showed that risk-averse students may be disadvantaged by excessive use of certain types of questions and marking methods, for example single answer questions with negative scores [6].

At the NSA, we incorporate into MCQ tests questions of different types including single answer, multiple answer, calculated numeric, fill in black and matching questions. Negative scoring is applied only to a small number of multiple answer questions (typically less than 10% per test) and when applied, a chosen wrong option only negates marks for chosen correct answer on the same question, and there is no overall negative score for a question. In future, we plan to broaden the range of the types of MCQ questions by incorporating elimination format questions in order to reward partial and full knowledge, and avoid gender discrimination [10].

2.3 Future Measures

Learning Material. One measure we will implement in the future, is to review the course material for unconscious bias as suggested in [16]. We will implement a rigorous process to identify any wording, imagery or representation that could carry any type of unconscious bias or stereotypes. These unconscious bias or stereotypes, present in learning materials, can decrease the confidence of people belonging to a minority when they are reinforcing harmful stereotypes [16]. For example, course material using examples such as every man loves a woman ($\exists y.woman(y) \wedge (\forall x.man(x) \Rightarrow Love(x, y))$) should be avoided and replaced by an example that does not carry any hetero-normative stereotypes. When implementing these new measures, we will not only look at the material we are creating, but also look at the external material such as books proposed to students. It is not realistic to get rid of all the material that carries unconscious bias, but offering an alternative should be the aim we are striving for. It could be a challenge to propose that in academia, as it could also go against academic freedom. Academic freedom is the choice of academic staff to research and teach whatever they want, without being targeted for repression, job loss, or imprisonment.

Diversity and Gender Balance In University Events. Another measure is to ensure that for every event organised by the university, the ratio of women to men is taken into account and the academic staff present during the event will be as diverse as possible. For example, UK universities have several Open Days per year, where

prospective students are invited to visit the university, departments or schools of their choice. Staff members are expected to come and represent the different schools. A fair representation of the diversity of the school should be expected, however, it could also have a side effect when the ratio of women/men is not equal by always having the same people being asked to participate. We want also to investigate, if having a good ratio women/men during the Open Day was noticed by the prospective students during their visit, and if it was a criteria in their choice to apply to Cardiff University, and in the different subareas. Another example is seminar and conference talks. The school is organising seminars for academic staff and graduated students. These talks are given by internal and external speakers about different themes such as research, teaching, industry and grant proposals. Until now, the ratio women/men was not taken into consideration when the organisation team was looking for speakers. The result is that most of the talks focusing on research or industry were given by men, especially when it was external guest speakers. In the future, the aim is to reach a good balance between women and men for all of the different themes proposed during the seminar. The aim of these seminars is to inspire people and inform people, but it should also be to propose roles models not only at lecturing time but any time and at any levels (undergraduate, graduate students and early academic staff).

Conversion Courses. From next year the NSA is introducing a Software Engineering master's degree. Students that don't have the level of computing literacy required will be able to follow a conversion course. Conversion courses can be a good way to attract women in software engineering, as they are already in the higher education system. Academic institutions and academic staff have better ways to reach them as they are already in the system, compared to undergraduate students who are not. We could investigate the background of these students, which discipline they come from (degree and field area), why are they converting, and their level of computing literacy.

Self-efficacy measures. Some investigations will be made to measure the difference of self-efficacy² between women and men when they need to achieve a programming or a soft-skill task. We will also analyse if a difference exists between their preferences of subjects in Software Engineering, and if these preferences are dependent of the level of self-efficacy and their sex.

3 CONCLUSIONS

Achieving gender equality and in general diversity is a very important goal for the School and for society, however, it is also a very difficult goal to achieve. Changes have to be made in society and not only in higher education institutions. However, higher education institutions can still implement measures to raise awareness and counter stereotypes and unconscious biases, and reduce the gap between women and men at all levels (students and staff). Solutions such as designing curricula and courses that will increase the confidence of women students. Creating conversion courses that will allow students to apply and be accepted to master degree

programmes in Computer Science or Software Engineering could be some of the measures that could help to reduce this gender gap.

This paper is the beginning of a longitudinal study within the described "controlled" applied environment of the newly established NSA, which will produce both qualitative as well as quantitative data to answer questions, and give insight into methods and reasons that benefit or hinder equality. It is our aim to discuss and collaborate with interested parties in order to enhance this data, both in qualitative as well as quantitative terms and also cross-examine the results with other culturally or operationally different institutions.

REFERENCES

- [1] 2017. Core STEM Graduates 2017. (2017). <https://www.wisecampaign.org.uk/resources/2018/02/core-stem-graduates-2017>
- [2] 2017. Women in STEM workforce. (2017). <https://www.wisecampaign.org.uk/resources/2017/10/women-in-stem-workforce-2017>
- [3] Albert Bandura. 1982. Self-efficacy mechanism in human agency. *American psychologist* 37, 2 (1982), 122.
- [4] Julia B. Bear and Anita Williams Wooley. 2011. The role of gender in team collaboration and performance. *Interdisciplinary Science Reviews* 36, 2 (2011), 146–153. <https://doi.org/10.1179/030801811X13013181961473>
- [5] Eric P. Bettinger and Bridget Terry Long. 2005. Do Faculty Serve as Role Models? The Impact of Instructor Gender on Female Students. *The American Economic Review* 95, 2 (2005), 152–157. <http://www.jstor.org/stable/4132808>
- [6] A Elizabeth Bond, Owen Bodger, David OF Skibinski, D Hugh Jones, Colin J Restall, Edward Dudley, and Geertje van Keulen. 2013. Negatively-marked MCQ assessments that reward partial knowledge do not introduce gender bias yet increase student performance and satisfaction and reduce anxiety. *PLoS one* 8, 2 (2013), e55956.
- [7] Nida Broughton. 2013. *In the balance: The STEM human capital crunch*. Social Market Foundation.
- [8] Natasha Codioli. 2015. *Inequalities in students' choice of STEM subjects*. Technical Report. CLS Working Paper 2015/6, Centre for Longitudinal Studies, UCL Institute of Education.
- [9] Wikipedia contributors. 2018. Google's Ideological Echo Chamber – Wikipedia, The Free Encyclopedia. (2018). https://en.wikipedia.org/w/index.php?title=Google%27s_Ideological_Echo_Chamber&oldid=824614878
- [10] Tinne De Laet, Jef Vanderoost, Riet Callens, and Joos Vandewalle. 2015. How to remove the gender bias in multiple choice assessments in engineering? Experimental validation and theoretical analysis using prospect theory. In *Proceedings of the 43rd Annual SEFI Conference*. 1–8.
- [11] Graham D. Fenwick and Derrick J. Neal. 2001. Effect of Gender Composition on Group Performance. *Gender, Work and Organization* 8, 2 (2001), 205–225. <http://onlinelibrary.wiley.com/doi/10.1111/1468-0432.00129/full>
- [12] Allan Fisher and Jane Margolis. 2002. Unlocking the Clubhouse: The Carnegie Mellon Experience. *SIGCSE Bull.* 34, 2 (June 2002), 79–83. <https://doi.org/10.1145/543812.543836>
- [13] Danielle Gaucher, Justin P Friesen, and Aaron C. Kay. 2011. Evidence that gendered wording in job advertisements exists and sustains gender inequality. *Journal of personality and social psychology* 101 1 (2011), 109–28.
- [14] HESA. 2017. Full-time academic staff (excluding atypical) by cost centre group, source of basic salary and sex. (2017). <https://www.hesa.ac.uk/data-and-analysis/staff/overviews?breakdown%5B%5D=583&year=2>
- [15] Antonio M Lopez Jr, Lisa J Schulte, and Marguerite S Giguette. 2005. Climbing onto the shoulders of giants. In *ACM SIGCSE Bulletin*, Vol. 37. ACM, 401–405.
- [16] Paola Medel and Vahab Pournaghshband. 2017. Eliminating Gender Bias in Computer Science Education Materials. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education (SIGCSE '17)*. ACM, New York, NY, USA, 411–416. <https://doi.org/10.1145/3017680.3017794>
- [17] UNESCO. 2014. *UNESCO Priority Gender Equality Action Plan, 2014-2021*. Technical Report.

²Perceived self-efficacy is concerned with judgements of how well one can execute courses of action required to deal with prospective situations [3]