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Gender Inequality in Cybersecurity: Exploring the Gender Gap in Opportunities and Progression

ABSTRACT

This paper considers the impact of gender in the cybersecurity industry. There is currently significant underrepresentation of females in the industry caused by low numbers of women entering the field and compounded by a high rate of women choosing to leave a highly male dominated work environment.

The findings are based upon a quantitative study conducted by means of an online survey. The research considers the motivations, experiences and progression of those working within cybersecurity roles with a focus predominantly on the UK. The findings from the research indicate that computer security offers an interesting, exciting and challenging work environment, job security, and excellent opportunities for progression and development. Barriers remain for women though; despite the perception that anyone with the 'right skills, knowledge and experience can work in cybersecurity', it is clear that the respondents to this study feel that computer security is viewed as a 'man's job' by wider society and by customers and clients and that there is perceived gender inequality in recruitment, opportunities and progression.

INTRODUCTION

Cybercrime and cyber attacks are increasing in number, complexity and sophistication. The Crime Survey for England and Wales (CSEW) estimated that there were 2 million instances of cybercrime experienced by victims in the 12 months prior to March 2016 in the UK (ONS, 2016). The National Crime Agency (2016) estimates that the cost of cyber crime to the UK economy is billions of pounds per annum – and growing. One of the ways to tackle cybercrime is through prevention which can be enhanced by robust and resilient cybersecurity, however, there is a huge shortfall in the skills required to address the cybersecurity requirements.

It has been suggested in a number of sources, for example in recent reports from the National Audit Office (2013), CPHC (2014; 2015), ISACA (2015), that there is a skills shortage in the cybersecurity environment (reported as a potential worldwide shortage of over 4 million cybersecurity professionals by 2017 ((ISC)², 2014), and 62% of employers were unable to fill their open cybersecurity posts in 2014 . The skills shortage is further exacerbated by the gender imbalance; research carried out by (ISC)² (2014) indicates that only 11% of the cybersecurity workforce is female in the UK. This is also reflected in the US where according to LeClair, Shih and Abrahams (2014) there is a 10-15%

representation of women in cybersecurity jobs. This point is emphasised in Bagchi-sen et al (2009:46) who suggest that "*although cybersecurity is a critical IT area, women continue to be underrepresented amongst its ranks*". According to Macdonald (2014: 6) "*...there is a business case for a more diverse workforce to increase productivity and creativity*". It is further suggested that there is a wide range of opportunities for women in cybersecurity and there is a critical need to embrace the female talent in the cybersecurity field (Divol, 2015).

Macdonald's (2014) contention that women in ICT are bound by dominant cultural conceptions of both gender and technology applies also to those women working in computer security, who are also bound by notions of security and masculinity (Hudson, 2005; Romaniuk and Wasylciw, 2010), so that the effect is further exacerbated (WSS, 2013). Hegemonic masculinity in society has meant that females do not associate their identities with security as their gender is more associated with the private sphere, rather, they are seen as being in need of protection (Romaniuk and Wasylciw, 2010). The result is that the already low numbers of women in ICT are further diminished by the 'security' aspects of cybersecurity work.

This paper considers entry routes to the industry, and opportunities and progression for those who have entered computer security roles. The data supports the popular perception of computer security as a 'male' industry, and further suggests that the causes of inequality in opportunities and progression lie in the social construction of a gendered labour force (Macdonald, 2014).

This paper is of current relevance as despite a recognised gender disparity within cybersecurity the subject has received limited attention in the academic literature. The gender imbalance is of special interest beyond its contribution to academic knowledge when considering the skills gap that the sector is attempting to close. It is also a matter of social justice for society to provide equal opportunities and progression within employment.

Whilst there has been a growing literature base with relation to girls into STEM, and girls into ICT, there is limited literature available which considers cybersecurity specifically. The proportion of females in information security globally is lower than in other ICT professions at only 11% according to research by (ISC)² (2014), as compared to approximately 15% in all ICT professions (Macdonald, 2014). This research aims to begin to address this gap in the literature with regard to gender and cybersecurity.

CONTEXT

In the UK, undergraduate Science, Technology, Engineering and Mathematics (STEM) numbers are currently on the increase with 2013-2014 seeing the highest number ever at 98,000 new entrants; the study of Computer Science

has risen by 13%, and Engineering and Technology entrants are up 11% on 2012-2013 entries (HEFCE, 2014). Information Communication Technology (ICT) is taken up at a greater rate by men than it is by women, with an increase of 7% of new male entrants, and a decline of new female entrants of 15% between 2012 and 2014, so that females make up 15% of graduating UK ICT professionals (Macdonald, 2014).

A number of reasons have been suggested for this gender imbalance in ICT roles. Firstly it has been suggested that despite the fact that girls outnumber and outperform boys in STEM qualifications (Macdonald, 2014), girls do not aspire to work within the technology industry as they perceive it to be 'geeky' (WSS, 2013), 'nerdy' (Valenduc, 2011) or 'for boys' (techwomenuk, 2015a) and therefore they do not see it as being in line with their self perceptions (Macdonald, 2014). 'Non-stem' identities in girls are thought to emerge as early as the age of ten or eleven (techwomenuk, 2015b). Sanders (2005: 6) suggests that the causes may be within the ways in which technology has been socially constructed and in particular that:

The violent language of technology may be invisible to males but can be a problem for females. Consider hard disc, hard drive, reboot, cold boot, hits, permanent fatal error, and so forth. Recreational or even educational software for children often includes title words such as "attack" or "war".

Other reasons suggested for girls not aspiring to work in technology are lack of familial encouragement (techwomenuk, 2015b, Denner, 2011), possibly due to a lack of parental knowledge and/or confidence in technology (techwomenuk, 2015a; 2015b), lack of early engagement (techwomenuk, 2015a) lack of encouragement within schools a lack of appropriate careers education (techwomenuk, 2015a; Macdonald, 2014), and a lack of female role models (LeClair, Shih and Abrahams, 2014; techwomenuk, 2015a; 2015b). These factors could impact upon the aspirations of girls, and their awareness of opportunities within the industry.

It has also been suggested that technology as a profession has been more likely to be aspired to by boys because boys were more likely to engage with it for recreational purposes, particularly in gaming (Palmén, 2011). Evidence suggests however that girls do in fact engage with technology recreationally, being much more prolific users of social media than boys (Johnson, 2008) meaning that we cannot therefore point to the extent of recreational use of technology among young people as a cause of gender differences within ICT employment roles.

The proportion of females in information security globally has been found to be lower than is found in other ICT profession, currently at only 11% according to research by (ISC)² (2014) as compared to 15% in all ICT professions (Macdonald, 2014). The security sector as a whole is male dominated, perhaps due to its traditional corporeal and therefore physical traditional character; many

of those working in cybersecurity have previously worked in other areas of security work (WSS, 2013). Gender inequality in ICT more generally is compounded due to the masculinisation of both security (Romaniuk and Wasylciw, 2010) and technology (WSS, 2013), with security being “based on a hegemonic masculinity” (Romaniuk and Wasylciw, 2010: 26) and with technology being a “...*fundamental way in which gender is expressed in any society*” (Bray, 2007: 38). There are a number of potential reasons for this – partly due to the lack of women going on to study computing subjects at university. The reasons for women not going to higher education to study are multifaceted and include a lack of female teachers in STEM subjects in schools, dissuading females from studying STEM (Wajcman, 2004). Similarly computing departments in UK universities tend to be male dominated and therefore potentially fewer opportunities for mentoring and guidance for female students.

This imbalance of gender distribution in technology related roles has been attributed to a “...*lack of standardisation and formalisation in career paths and qualifications/training required*”, and a lack of awareness amongst women of the variety of roles that are available (WSS, 2013:3).

There is also a wide range of reasons for poor retention of women (Valenduc, 2011) suggested including a 23% pay gap (Macdonald, 2014), discrimination (Weisul, no date), and lack of advancement due to “*social, institutional and personal challenges*” (Bagchi-Sen *et al.*, 2009: 47). LeClair, Shih and Abrahams (2014: 2) suggest “...*climate dissatisfaction, pay inequity, pressure from family issues, gender discrimination, lack of social change, lack of support from employers for advancement*”. It is clear that the retention of women is difficult for a number of reasons; these are complex and are both internal and external to organisations in which cybersecurity professionals are employed.

It is desirable for businesses to consider the causes of the gender divide because it has been found that workforce diversity increases productivity and creativity (Macdonald, 2014), and gender diverse organisations significantly outperform male only organisations, with gender diverse companies found to be outperforming those with male only workforces by up to 26% (Caldwell, 2013). It has been suggested in previous research that increased gender equality is beneficial to cybersecurity because of the ‘different’ personal attributes offered by women ((ISC)², 2013). What is less clear is whether women do actually have these ‘different’ attributes (according to Wajcman (2004) feminist perspectives on technology are divided on this issue), and if so, what they are, and whether they are biologically inherent, or are socially constructed. While this is beyond the scope of the current research, it is certainly worthy of further investigation if we are to build a comprehensive picture of the causes and consequences of gender inequality in cybersecurity.

There is a significant skills shortage in the industry (ISC)² (2014); this could potentially be met and simultaneously offer some much needed diversity to the

workforce by attracting more women into the sector (Divol, 2015). It is suggested in this paper that it is important that academics, researchers and policy makers consider the gender divide in order to fully understand the causes. It is only by developing an understanding of the generative mechanisms that underlie inequality that solutions may begin to be produced. These solutions must focus upon wider society, parents and education, as well as the industry itself, in order to begin to tackle gender inequality at its roots.

METHODS OF WORKING

This study has utilised a quantitative approach to examine the impact of gender upon perceived opportunities and progression opportunities for those employed within computer security roles. The data in this survey was collected using an online survey, which was completed by 219 individuals working within the sector in the UK and beyond (27% of the respondents were working outside of the UK). 33% of the survey respondents were female, which over-represents the distribution of females in the industry, and may be indicative that males were less likely to be interested in completing the survey when invited to do so.

The survey was disseminated online, utilising the professional networks of individuals engaged within the sector. In many respects this makes the sample a convenience sample and the results should be considered with this in mind.

As the survey responses were mainly in the form of ordinal and nominal data it was possible to crosstabulate the responses (Wagner, 2015) by gender for the purpose of considering the differences in responses relating to perceptions from male and female respondents. Crosstabulation is a form of bivariate analysis that allows for statistical analysis of the relationship between variables (Frankfort-Nachmias and Leon-Guerrero, 2015). A chi square calculation was undertaken in order to test for statistical significance. Data that were calculated to be statistically significant ($p < 0.05$), and therefore unlikely to be merely random occurrences in the data (a less than 5% chance), have been included in the discussion that follows. In addition, the discussion is supported by qualitative comments that were made within the survey, where respondents were invited to add any further comments that they felt may be of relevance to the research.

FINDINGS

The findings from the research indicate that computer security offers an interesting and challenging work environment, job security and excellent opportunities for progression and development. 93% of respondents agreed or strongly agreed that the work is interesting, 89% agreed or strongly agreed that it is challenging, and 73% agreed or strongly agreed that it is exciting. 80% of

the respondents were in full time permanent positions and 59% agreed that they are fairly paid for the work that they do, with no significant difference found here between male and female responses.

86% of the respondents agreed that 'anyone with the right skills and attributes can work on cybersecurity'; it would seem however that being female is not 'the right attribute', only 50% of the respondents agreed or strongly agreed that men and women are equally valued within the industry. Respondents also perceived significant differences in recruitment, opportunities, and progression.

Table 1. (below) shows that there is a significant difference in the perceptions of males and females with regard to whether males and females are equally likely to be recruited; only 25.4% of females (n=16) agreed that men and women are equally likely to be recruited compared to 52.7% of males (n=69) agreed (p=0.00), showing that male respondents to the study perceive there to be more equality of opportunity than women do. Females were more than four times as likely to strongly disagree that men and women were equally as likely to be recruited as were males, who were more than eleven times as likely to agree.

Male participants clearly perceive there to be more equality in recruitment opportunities than is perceived by females; it could be suggested that females were more likely to perceive inequality because they were more likely to have had experience of inequality in their own career although further research is required in this area.

Table 1. 'Men and women are equally likely to be recruited to work in computer security'

	Female (count and percent)	Male (count and percent)
Strongly Disagree	10 (15.9%)	5 (3.8%)
Disagree	26 (41.3%)	30 (22.9%)
Neither Disagree Nor Agree	11 (17.5%)	27 (20.6%)
Agree	15 (23.8%)	45 (34.4%)
Strongly Agree	1 (1.6%)	24 (18.3%)

This is partially explained within the qualitative responses as being related to "the lack of women in IT in general [which] means that there are even fewer entering the IT Security field... for many people IT Security is a progression from a more generalist IT role" (Respondent 218). As Respondent 197 goes on to

explain further "...there are feeder roles for entry level security analysts, mainly from technical roles. This makes the pool of available applicants statistically skewed in favour of men, because there just aren't as many women in those roles". This may suggest that in order to gain a better gender balance in this workforce it is necessary to further consider the different routes by which males and females enter the industry.

Table 2. (below) shows that 24.6% (n=15) of females agreed or strongly agreed that they were encouraged by their family to do cybersecurity work; only 9.6% (n=12) of males agreed or strongly agreed (p=0.016). No difference was found between male and female reporting of encouragement in education where responses indicated low levels of encouragement, as one of the respondents to the study stated "...women are not encouraged or inspired to enter into the industry" (Respondent 150).

Table 2. 'I was encouraged to do cybersecurity work by my family'

	Female (count and percent)	Male (count and percent)
Strongly Disagree	12 (19.7%)	28 (22.6%)
Disagree	23 (37.7%)	45 (36.3%)
Neither Disagree Nor Agree	11 (18%)	39 (31.5%)
Agree	13 (21.3%)	7 (5.6%)
Strongly Agree	2 (3.3%)	5 (4%)

The higher level of perceived familial encouragement among females must be considered within the context of the study; these are participants who have entered the industry. The higher level of encouragement perceived may therefore indicate that females *require more encouragement* than males do in order to enter the industry, rather than that females are actually encouraged more.

Females were more likely to report that they were unable to effectively access information about how to access the industry. As shown in table 3. (below) 40% of females (n=24) perceived an inability to effectively access information about how to access the industry compared with only 23% (n=28) of males (p=0.011).

Table 3. 'I was able to effectively access information about how to access the cybersecurity industry'

	Female (count and percent)	Male (count and percent)
Strongly Disagree	2 (3.3%)	10 (8.2%)
Disagree	22 (36.7%)	18 (14.8%)
Neither Disagree Nor Agree	12 (20%)	41 (33.6%)
Agree	22 (36.7%)	50 (41%)
Strongly Agree	2 (3.3%)	3 (2.5%)

This inability to effectively access information about careers in cybersecurity strongly suggests a need to tackle careers advice and guidance for all genders, and specifically to ensure that useful and relevant information is made available to girls who perceived more difficulty in this area. The lack of encouragement in education is perceived by both males and females.

86.23% (n=169) of respondents agreed or strongly agreed that 'anyone with the right skills and attributes can work in cybersecurity' (weighted average 4.23), with no statistically significant differences found between the responses that were given by male and female respondents.

Table 4 however shows that there is a clear difference in male and female perceptions of whether both genders are equally valued within the industry. 31.7% of females (n=20) agree that men and women are equally valued within the industry while 59.6% of males (n=78) agreed (p=0.00).

Table 4. 'Men and women are equally valued in my industry'

	Female (count and percent)	Male (count and percent)
Strongly Disagree	7 (11.1%)	4 (3.1%)
Disagree	25 (39.7%)	21 (16%)
Neither Disagree Nor Agree	11 (17.5%)	28 (21.4%)
Agree	16 (25.4%)	53 (40.5%)
Strongly Agree	4 (6.3%)	25 (19.1%)

While there is strong agreement that men and women are equally valued in the industry it is important to note that this was stronger among male respondents. The qualitative comments reveal that gender discrimination occurs. One respondent suggests that women in the industry may be subject to practices of positive discrimination whilst simultaneously revealing negative stereotypical assumptions about women's competencies and behaviour. *"The women never attract the blame for security failure, again, because of their gender and they won't be singled out as a 'soft target'; the senior personnel wouldn't dare! Women don't handle high pressure security incidents well and frequently come over as aggressive and point-scoring"* (Respondent 55). Respondent 34 states that she feels that she has *"...to try and be the right kind of woman to get ahead"*.

Table 5. shows that only 15.9% (n=10) of females agreed or strongly agreed that men and women are equally likely to be promoted to senior positions; males were more than 3 times as likely to agree or strongly agree (47.7% (n=62) of males (p=0.00)). This reveals that there is the clear perception among respondents that there is inequality in promotion opportunities, and that the problem is perceived by to be worse by women than it is by men.

Table 5. 'Men and women are equally likely to be promoted to senior positions in cybersecurity'

	Female (count and percent)	Male (count and percent)
Strongly Disagree	14 (22.2%)	5 (3.8%)
Disagree	24 (38.1%)	25 (19.2%)
Neither Disagree Nor Agree	15 (23.8%)	38 (29.2%)
Agree	7 (11.1%)	42 (32.3%)
Strongly Agree	3 (4.8%)	20 (15.4%)

These perceived inequalities and opportunities may be attributed to the perception that cybersecurity roles are seen as 'men's jobs' within the industry, by customers and clients, and also more widely by society as shown in tables 6-8 below. Customers and clients are believed to display this prejudice, but less strongly than within the industry, with the highest levels of prejudice perceived to be within wider society.

As shown in table 6, there is the significant (p=0.00) perception among the respondents that cybersecurity jobs are seen as 'men's jobs' within the industry (a total of 53.9% agree or agree strongly, n=103), although this perception is significantly stronger among females than among males with 74.2% (n=44) of females agreeing or strongly agreeing with the statement compared against

43.9% (n=57) of males.

Table 6. 'Cybersecurity roles are seen as 'men's jobs' within the industry'

	Female (count and percent)	Male (count and percent)
Strongly Disagree	0 (0%)	9 (6.9%)
Disagree	8 (12.9%)	36 (27.7%)
Neither Disagree Nor Agree	8 (12.9%)	28 (21.5%)
Agree	33 (53.2%)	50 (38.5%)
Strongly Agree	13 (21%)	7 (5.4%)

Table 7 (below) shows that there is the significant ($p=0.00$) perception that cybersecurity jobs are seen as 'men's jobs' by customers and clients. This perception is stronger among females than among males with 66.2% (n=41) of females agreeing or strongly agreeing with the statement compared against 36.6% (n=48) of males.

Table 7. 'Cybersecurity roles are seen as 'men's jobs' by customers and clients'

	Female (count and percent)	Male (count and percent)
Strongly Disagree	0 (0%)	9 (6.9%)
Disagree	5 (8.1%)	32 (24.4%)
Neither Disagree Nor Agree	16 (25.8%)	42 (32.1%)
Agree	29 (46.8%)	43 (32.8%)
Strongly Agree	12 (19.4%)	5 (3.8%)

As shown in table 8 (below), there is the significant ($p=0.00$) perception that cybersecurity jobs are seen as 'men's jobs' in society, again, this perception is significantly stronger among females than among males with 84.1% (n=53) of females agreeing or strongly agreeing with the statement compared with 53.4% (n=70) of males. .

Table 8. 'Cybersecurity roles are seen as 'men's jobs' in society'

	Female (count and percent)	Male (count and percent)
Strongly Disagree	0 (0%)	7 (5.3%)
Disagree	2 (3.2%)	20 (15.3%)
Neither Disagree Nor Agree	8 (12.7%)	34 (26%)
Agree	41 (65.1%)	59 (45%)
Strongly Agree	12 (19%)	11 (8.4%)

The perception indicated in tables 7 and 8 is that there is more gender typing apparent in wider society than that which occurs within the industry. This would appear to conflict with the demographic data relating to gendered distribution of job roles inside the industry, and may also be a contributory factor to reinforcement of the inequality within the industry; employers may be reluctant to employ people who they perceive not to fit with the customer or clients perceptions regarding who typically conducts these roles.

Overall, there is perceived to be gender difference in careers advice and guidance offered and availability of information and support, there is perceived inequality in recruitment and promotion, and it is also suggested that there is gendered stereotyping in relation to job roles. The inequalities that are perceived in these areas are considered to be greater by the female respondents; females may have a higher level of awareness of inequality within the industry as they are more likely to have experienced it directly.

DISCUSSION

It has been previously suggested that girls do not aspire to employment in technology professions because of wider social constructions of gender impacting on their identity (Macdonald, 2014; techwomenuk, 2015a; 2015b). This is thought to be because security is a male domain (Romaniuk and Wasylciw, 2010) and because "*technology is firmly coded male*" (Bray, 2007: 38). The masculinisation of both security and technology have led to lower numbers of females in cybersecurity than in other IT professions.

Denner (2011: 56) stated that "*high school girls who express interest in a computing career are more likely to believe their parents support this choice*". Females in this study were more than twice as likely as males to report that they were encouraged by their family to do computer security work. It must be noted

that this is within a sample of respondents who self report working within the industry presently or recently, and therefore indicates that women may need more encouragement from their families than males do in order to choose to enter cybersecurity, and not necessarily that females in the wider population are subject to higher levels of familial support than males. It is notable that there was no difference perceived by either males or females in levels of encouragement in education, suggesting that familial support may be of more importance in encouraging entry to computer security work than educational support. Despite this perceived parity in encouragement, there is still work to be done within the education system, and by the industry, as the respondents to this study reported significant differences in their ability to access information about how to enter the industry, with females being almost twice as likely to disagree that they were able to do this effectively. This reflects previous suggestions that there is a lack of appropriate careers education relating to technology careers (techwomenuk, 2015a; Macdonald, 2014). It is essential that the perceptions of young women in relation to careers in cybersecurity are challenged. Rather than being 'geeky' (WSS, 2013), or 'nerdy' (Valenduc, 2011) this study has shown that cybersecurity work is perceived by employees within the field to be interesting, exciting, and challenging.

This study has found that there are significant differences in male and female perception of equality of opportunity in entering the profession. According to WSS (2013) the inequality in recruitment opportunities may be due to 'like for like' recruiting patterns, whereby males recruit other males. This finding is of importance due to the male dominated nature of the industry (Macdonald, 2014; WSS, 2013); if males, who are likely to make up the majority of senior staff and management given that they numerically dominate the industry, do not perceive that there is inequality they are unlikely to take steps to increase equality in this area. The lack of perceived equality in access to information and in recruitment revealed by the survey data may also go some way to explaining why such restricted numbers of females enter the industry.

What is also of concern is that there is the perception that men and women are not equally likely to be promoted to senior positions. This may be suggestive that there is not only an issue around recruitment, but also around retention, as women may feel more inclined to leave an industry where they are unable to advance their career progression and where they suffer pay disparity (LeClair, Shih and Abrahams, 2014), this research has shown no difference in male and female perceptions of whether they are paid fairly, but has not investigated pay and reward. Valenduc (2011) describes the situation not as only a 'glass ceiling' but also as a 'sticky floor' pointing out that pay inequality in ICT begins at the recruitment stage, with males being contracted on higher salaries than female counterparts with equal skills knowledge and experience.

There was strong agreement in this study that 'anyone with the right skills and attributes can work in computer security'. Despite this, the respondents showed

a clear gendered difference in their perceptions of whether men and women are equally valued within the industry, with men almost twice as likely to report that they perceived equality in this area, and less than one third of women agreeing. This raises questions about what exactly the 'right skills and attributes' are, and also the suggestion that the 'right skills and attributes' may be those that are perceived to be masculine traits.

There is a clear perception that women are not equally likely to be promoted to senior positions as men. Females perceived heightened inequality in progression opportunities compared to males which is of concern as less than half of the male respondents agreed that they perceived there to be equality in this area. Whilst this may reflect the pattern in the wider ICT industry, the effect is magnified in cybersecurity, possibly because there are so few women in the sector. This may also be in part due to "*the current construction of the male as protector and the woman as dependant*" (Romaniuk and Wasylciw, 2010: 26) which then precludes females from being valued equally in a predominantly masculinised industry.

The key findings presented here raise particular issues that are suggestive of the need for further research, particularly given the very limited available literature that is specific to cybersecurity. Parent's perceptions, teacher's perceptions, and careers advisor's perceptions of ICT and cybersecurity, and the impact of these upon young people's career aspirations should be further investigated.

CONCLUSIONS

There is an under-representation of women in cybersecurity jobs; addressing this issue will contribute to tackling the number of unfilled vacancies in the sector. This is of importance to the industry, and to society in order to deal with the growing threat posed by cybercrime. Perhaps more importantly, it is a matter of social justice that there should be equality of opportunity in access to and progression within a well paid and intellectually stimulating work environment.

In order to encourage female participation there is a need for an increase in female role models to encourage an increase by reducing the likelihood of 'non-STEM' identity development. Given the importance for females of familial support in entering the industry, and the early stage at which girls have been found to form STEM or non-STEM identities possible future solutions may be in educating parents and families about the opportunities that computing and cybersecurity can offer to their daughters in terms of the exciting, interesting, creative, varied, and stimulating nature of the work.

In order to ensure that there is the flow through of female participants in cybersecurity there is a need to encourage females at school, in FE and in HE to

study the computing disciplines and to further provide the opportunity to focus on cybersecurity opportunities. It is also clear that the industry must work to reduce the impact of, and perception a "sticky floor" and a "glass ceiling" in terms of opportunities for progression and pay in order to increase the likelihood that women will enter the industry, and that those who do enter the industry will choose to stay.

The causes of gender inequality in cybersecurity are complex. The roots of inequality are found within social constructions of gender, within wider society, within families, within education, and within the ICT, security and cybersecurity industries. Any attempts to reduce the gender gap will take time, and will need to tackle the problem from all of these angles in order to provide a solution. It is time for the perception that cybersecurity is 'for boys' to be challenged so that the industry can fill its skills shortage, so that girls can access an exciting and stimulating career, and so that society is better equipped to deal with the growing threat posed by cybercrime.

REFERENCES

Bagchi-Sen, S, Rao, H.R., Upadhyaya, S. (2009) "Women in Cybersecurity: A Study of Career Advancement" in *IT Pro*: IEEE

Bray, F. (2007) "Gender and Technology", *Annual Review of Anthropology* [Online]. Available at www.arjournals.annualreviews.org

Caldwell, T. (2013) "Plugging the cyber security skills gap", *Computer Fraud & Security*, (7), 5-10.

CPHC (2014) Workshop on cybersecurity skills development 1, London November 2014

CPHC (2015) Workshop on cybersecurity skills development 2, London March 2015

Divol, R. (2015) "Career Path for Women in Cyber Security", paper presented at *Women in Cybersecurity Conference*, Atlanta, GA, March 27 – 28, 2015

Denner, J. (2011) "What Predicts Middle School Girls' Interest in Computing?" *International Journal of Gender, Science and Technology*, 3(1): 53-69

Frankfort-Nachmias, C. and Leon-Guerrero, A. (2015) *Social Statistics for a Diverse Society* (7th edn.) London: Sage

(ISC)2 (2013) *The 2013 (ISC)2 Global Information Security Workforce Study* [Online]. Available at www.isc2.org

(ISC)² (2014) *Cybersecurity within Computer Science Report* [Online]. Available at www.isc2.org

ISACA (2015) *2015 Global Cybersecurity Status Report* [Online]. Available at www.ISACA.org

Johnson, C. (2008) *Gender and attainment in ICT at KS4* (funded by Hampshire Inspection and Advisory Service) [Online] Available at www.pgce.soton.ac.uk/IT/Research/Gender/Johnson2008.pdf

Hudson, H. (2005) "Doing' Security As Though Humans Matter: A Feminist Perspective on Gender and the Politics of Human Security" *Security Dialogue*, 36 (2): 155-174

LeClair, J., Shih, L., and Abraham, S., (2014) "Women in STEM and Cyber Security Fields", *Proceedings of the 2014 Conference for Industry and Education Collaboration*, American Society for Engineering Education, Savannah, GA, February 2014

Macdonald, A. (2014) "Not for people like me" *Underrepresented groups in science technology and engineering: A summary of the evidence: the facts, the fiction and what we should do next* Bradford: WISE

National Audit Office (2013) *The UK cyber security strategy: Landscape review* [Online]. Available at www.nao.org.uk/wp-content/uploads/2013/03/Cyber-security-Full-report.pdf

National Crime Agency (2016) *NCA Strategic Cyber Industry Group Cyber Crime, Cyber Crime Assessment 2016* [Online]. Available at <http://www.nationalcrimeagency.gov.uk/publications/709-cyber-crime-assessment-2016/file>

techwomenuk (2015a) *FE Leaders consider the challenge of encouraging more girls into tech Cybersecurity* [Online]. Available at www.techwomenuk.com

Office for National Statistics, (2016) *Crime in England and Wales: year ending Mar 2016*, available at www.gov.uk/government/statistics/crime-in-england-and-wales-year-ending-mar-2016

Palmén, R. (2011) "Girls, boys and ICT in the UK: an empirical review and competing policy agendas" *International Journal of Gender, Science and Technology*, 3(2), 407-23.

Romaniuk, S.N. and Wasylciw, J.K. (2010) "Gender' includes men too! Recognizing masculinity in security studies and international relations" *Perspectives* 18(1), 23-39

Sanders, J. (2005) *Gender and technology in education: a research review* [Online]. Available at www.josanders.com/pdf/gendertech0705.pdf

Valenduc, G. (2011) "Not a job for life?: Women's progression, conversion, and dropout in ICT professions" *International Journal of Gender, Science and Technology*, 3(2): 483-500

Wagner, W. (2015) *Using IBM SPSS Statistics for Research Methods and Social Science Statistics* (5th edn.) London: Sage

Wajcman, J. (2004) *Technofeminism* Cambridge: Polity

Weisul, K (no date) *It's the Culture Bro: Why Women Leave Tech* [Online]. Available at www.inc.com

WSS (2013) *Women in Cybersecurity* [Online]. Available at www.womenssecuritysociety.co.uk