The Gender Gap in Computer Science

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PGCE Lifelong Learning

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Research into the gender gap between students choosing to study for a degree in Computer Science

PGCE Lifelong Learning

Thames Valley University

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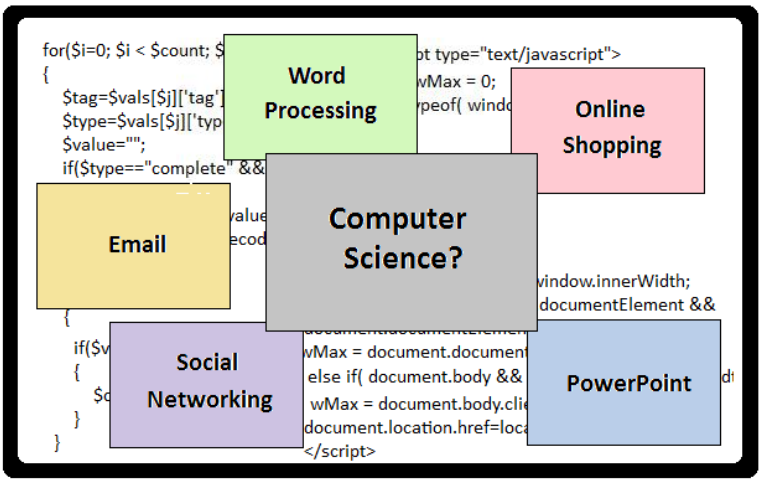

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1 Summary

Over the past decade, the percentage of women taking Computer Science as a University Degree has declined. Initial research suggested a number of possible reasons including females being turned off by ICT, negative geek stereotypes and females not being prepared to risk taking a degree in a subject which they know little about

The Primary research indicated that females are becoming increasingly confident with ICT and several would consider ICT as a degree subject. In comparison, the reason these students gave for not considering Computer Science was that they had not studied it and knew little about the subject. The industry was also seen as male dominated with stereotypes which did not attract females. Many attributes associated with computer scientist were also considered to be male attributes but not female ones.

Yet computer science requires creativity and imagination which were both considered to be female attributes. With women increasingly using computers the industry would benefit from higher female representation. Yet while most students have no exposure to computer science in education, females will remain reticent to risk choosing to study a subject they know little about and is seen as male dominated.

2 Introduction

Today computers are everywhere and used as much by women as they are by men. Yet this is not reflected within the numbers of women who are choosing to study computer science at university and then following it as a career path.

As a female, I pursued a career in software engineering for almost 25 years. When I entered the profession, I noticed that there were more males than females, but the difference was not substantial. There was even a department for home workers consisting predominately of women with children and was consequently nicknamed “The Pregnant Programmers”!!

Over time, I noticed a decline in the number of female software engineers where I worked but did not know whether this was representative of the industry as a whole. I then became aware that, of those studying for a degree in computer science in my daughters year at her university, only about 10% were female and was surprised that the figure was so low.

These figures are backed up by evidence from the UCAS statistics which show that, over the last decade, the percentage of females from the UK who choose to study computer science at a British university is just 12% (Appendix A: Table A.6). Of more significance, Carter (2001) noted that, despite Computer Science‘s increased popularity over the years prior to 2001, the number of females studying Computer Science had not just decreased proportionately, declining from 35% in

the early 1980s to closer to 10% in 2000, but was also decreasing in the actual number, compared to an overall increase of 150%.(Appendix A: Table A.7).

The question which this research will attempt to answer is

> *"Why has the gender gap between those taking computer science as a university degree increased over the past decades and what are contributing factors?"*

Computers were first introduced into schools and homes during the early 1980s. There were few applications and it was easy to experiment with writing and running computer programs allowing people to gain some insight into what software engineering was about.

Today, the first encounter with Computers for many students is through games, educational software, office tools and the internet. The steps required to write a computer program are complex and the process is no longer obvious. Although ICT is statutory within the curriculum, it usually does not include any programming content, leaving students knowing little about the subject of computer science.

Many students take qualifications within the lifelong learning sector which lead them to their chosen degree, or from which they can later decide to choose a degree subject. FE establishments can enable students to attain their chosen goal or create opportunities to allow students to be adequately informed about the options which are available. It is within this role that they could, with the right

information and resources, change the current trend and encourage more females to consider the option of studying computer science as a degree.

Those wishing to study Computer Science often choose to take A-Level Mathematics and, for some universities, it is a requirement. This is because there is an element of computer science which is considered to be Mathematical and requires a similar logical mind set. In comparison, although ICT “A Level” might appear to be an obvious pathway, this is not the case. Both subjects are closely linked through their use of computers, but they are different in content. ICT is about the use of applications and how they relate to the world of work. Computer Science is about the creation of these applications.

As a Maths teacher, many students which I will be teaching may have the aptitude for computer science but will not consider the subject as a degree choice as they are not fully informed. Researching the gender gap questions, should provide a better insight into the issues and indicate ways of how to inform students about computer science.

Another pathway to computer science is through vocational qualifications, such as the BTEC National Award for IT Practitioners, a qualification provided by many FE Colleges. Looking at the figures of those who have enrolled on these courses at TVU in the 2 past years, it is apparent that these courses are also male dominated and are failing to attract women (Appendix A: Table A.8).

The aim of this research is to look at all of the factors which have influenced the decline in female participation in qualifications which lead to a career in Computer Science using both primary and secondary data, and to consider whether there are ways in which this decline can be reversed.

3 Contextual/Theoretical Setting

According to Larmour and Tener (2000), during the 1950s and 1960s, almost half the number of programmers and system analysts were female and in 1975, 25% of Computer Science applicants were female and this was predicted to grow.

The decline in female representation in Computer Science at both degree level and in industry has been substantial and the opposite of what James Johnson (1982), (cited by Sanders, 2007, p.307) thought when he speculated that the new field of computer science held promise as there wasn't the history of male dominance which other science subjects had.

So what are the reasons for this? There are a number of published sources on the subject which suggest various reasons. The following are some of the ones worth noting.

3.1 Is There A Difference Between the Genders?

Books on the gender gap in Mathematics often assess whether there is a genetic difference between the genders in Mathematical ability. For instance, Gallagher and Kaufman (2005) look at a number of different contributing factors.

Books on the computing gender gap don't appear to focus on this issue but instead look at the issue of confidence. Margolis and Fisher note that research has shown women to be less confident in their Maths ability and so are more reticent to take optional courses related to Maths, which includes computing.

Saunders (2007, pp.311-313) concludes from the research that “Females consistently underestimate their technology skills regardless of what their skills really are” and later notes that both genders believed males to be better than females at computing.

One difference which has been noted between the genders is in their programming style. Cooper and Weaver (2003, pp.31-33) talk about two styles of computer programming, the “Formal” style which tends to be preferred by men and the “Concrete” style which tends to be preferred by women. The formal style is often taught in Universities as the “correct” way to program although both can lead to equally as good final products.

3.2 ICT Turning Off Girls

Does ICT in schools turn girls off computing? Carter (2001) notes that girls happily played with computers until ICT became compulsory in schools.

Cooper and Weaver (2003, pp.19-39) look at Education Programs which are designed to motivate students and believe that the features designed to motivate students can cause anxiety in either gender. Programs which include “Male preferred features”, such as shooting and destruction, cause increased anxiety in girls whereas programs with formal features and straightforward lessons increased anxiety in boys. Their research also shows that girls experience more anxiety than boys when computing in a public place (pp.54-55) and looks at the effects of the single sex classroom (pp.129-152).

The article from Deakin University (2008) looks at why girls shun IT in schools in Australia, observing the fact that many girls enjoy using computers for their personal use but find it uninteresting within schools where their experience is of having to “perform basic and repetitive” tasks.

Schelhowe (2003) notes that computer software “focuses on young white male users, who also dominate the development teams” and consolidates the software preferences which already exist.

Conversely, Margolis and Fish (pg 41) note that boys, from the age of 8, spend at least twice as long as girls playing video games and Saunders (2007, p.310) says that games are often one of the reasons which researchers give for boys increased computing experience.

3.3 Females are less likely to take Risks

Some educational establishments offer A-Level Computer Science, but the statistics from the JCQ national results show that the numbers taking this qualification have been in decline (Appendix A: Table A.3). This means that most student risk specialise in computer science qualification with no previous experience of studying the subject.

Carter (2001) reports that the careers advisor, whom she interviewed, suggested that girls are conservative about their choice of degree programme and tend to opt for subjects which they have studied at A Level. If educational establishments do

not offer the option of Computer Science, then females are less likely to consider the subject as a degree choice.

3.4 Lack of Role Models and Cultural Stereotyping

Carter (2001) argues that a possible reason for the decline in females studying computer science is due to the lack of Role Models. In the past these have including Ada Lovelace and Grace Hopper. She writes that, since the 1980s, the role models within Computer Science have become males and often known for their “geekyness”, something which does not appeal to women.

An article by Kendall (2009), (cited by Science Daily 2009) suggests that the nerd stereotype is as prevalent as ever and is turning off women from careers in IT. The hope was that as more people used computers, this stereotype would disappear, but there is a difference in people’s perception between those who use computers as part of their daily life and those whose involvement with them is more extensive. Walsh (2009) concurs with this and discusses research which shows that women looking for a career in computing are often put off by the IT workplace containing Science Fiction type objects and posters.

Parents can also promote the stereotype that computing is for boys. According to Saunders (2007, p.308) parents give less computer related support to girls than to boys.

4 Methodology

4.1 Topic for Investigation

The initial topic for research was to find out why there were apparently fewer women applying to do a degree in Mathematics or Computer Science.

Evidence from the UCAS web site showed that only 40% of the applications from the UK in 2008 for degrees in Mathematics were from women, compared to 57% of the total degree applications. This is less than what may be expected given that in recent years girls have performed better than boys at both GCSE and A-Level. (Appendix A: Tables A.1 and A.4)

However of even more interest were the figures relating to Computer Science which showed that only 13% of UK applications were from women. This led to the focus of the research focusing on the issues relating to Computer Science.

A review of literacy sources produced information from both books and articles on the web. This indicated that the gender gap for applications to study Computer Science had widened substantially over the past decades. In discussing the decline in numbers of women taking up Computer Science as a degree subject or a profession, possible reasons emerged including;

- The way in which ICT is taught at school
- The lack of role models and geek stereotypes

- The increased anxiety girls experience when expected to use computers in a public place
- Study pathways leading to a degree in Computer Science.

4.2 Primary Research

A questionnaire was used to obtain primary data (Appendix B). The reason for this approach was that, as some of the theories are related to cultural bias, then the more opinions which could be sought the better and a questionnaire was the easiest way of doing this.

The questionnaire was designed to investigate some of the points raised by the literature review in more depth and, in particular, establish the following

- Whether men are more likely to opt to study Mathematics, ICT and Computer Science
- To determine gender differences with respect to confidence in using computers
- To find out what attributes are associated with those who are good at Mathematics and Computing and whether there is a correlation between what are perceived to be male or female attributes.

To provide data which could be analysed, most questions were quantitative. The others were qualitative to allow for any additional insights

Bell (2005, p14) states that questionnaire wording is not easy and recommends piloting. The questionnaire was passed to 2 people who provided feedback and recommendations which led to some adjustments.

4.3 Ethical Considerations

The responses from the questionnaire will remain confidential and anonymous. Gender and occupation have been recorded against the qualitative responses but care has been taken to ensure that it is not possible to tell whose response it is.

When students who are under 18 have been asked to complete the questionnaire, permission to do this was sought from those in charge. The Head of the Maths department at TVU confirmed that the procedure of collecting data was within the college's protocols, with the proviso that the responses would be confidential.

The questionnaires contained statements confirming confidentiality and requesting that the responder should only provide the information which they feel comfortable providing.

The BERA ethical guidelines for educational research were checked to ensure that the research complied with them.

4.4 Reliability and Validity

To obtain reliable data, the questionnaire was circulated to as many people as possible and received 80 responses. Bell (2005, p.14) recommends the use of a representative sample and so by distributing the survey to a variety of people, responses were received from a good balance of students and adults of varying occupations of both genders.

Discussion concerning possible findings was not shared with any respondent until after they had completed the questionnaire so as not to prejudice their responses. Some of the questions contain a large range of suggested answers. When a respondent either failed to select any answer or selected all of the answers, their response for this question was not included in the final analysis as it had not been well considered and therefore not valid.

4.5 Analysis of the Data

The final stage of the research project was to compare the primary data with the review of the literature to see whether the findings concurred or whether something new emerged. By recording questionnaire responses in an Excel Spread Sheet, tables and graphical representations of information were generated enabling the data to be analysed.. Qualitative responses of interest have also been recorded to make any further conclusions as to the current situation. Some of the data from questions relating to the subject of Mathematics has not been included within this paper but may be useful for future research.

4.6 Working towards a Conclusion

The final stage was in looking at the conclusions which came out of the research, and suggestions of possible ways forward to try and reverse the current trends. Of particular interest are strategies which teachers and educational establishments could adopt to encourage females to consider a career in IT or Computer Science.

5 Presentation of Findings

5.1 Profile of Respondents

A total of 80 people responded to the questionnaire of which 29 were college or school students and 51 were either no longer in education or were in higher education. (Appendix C)

Of the students, 17 were male and 12 were female.12 were studying for GCSEs and 17 for Level 3 qualifications including 6 who were studying for the BTEC for IT Practitioners and 1 for AS Computer Science.

The other respondents consisted of 22 males and 29 females. including 10 teachers, 6 PGCE students and 6 software engineers. 7 had done a degree which included an element of computer science.

5.2 Use of Computers

Tables 1 and 2 show the percentages of respondents who used computers for a specific purpose. Of the BTEC students and those with a degree in computer science, a higher percentage used each type of application and were the ones most likely to develop web pages and write computer programs. Otherwise there was little variation between males and females. (Appendix F: Table F.1)

Table 1: Use of Computers among school and college students.

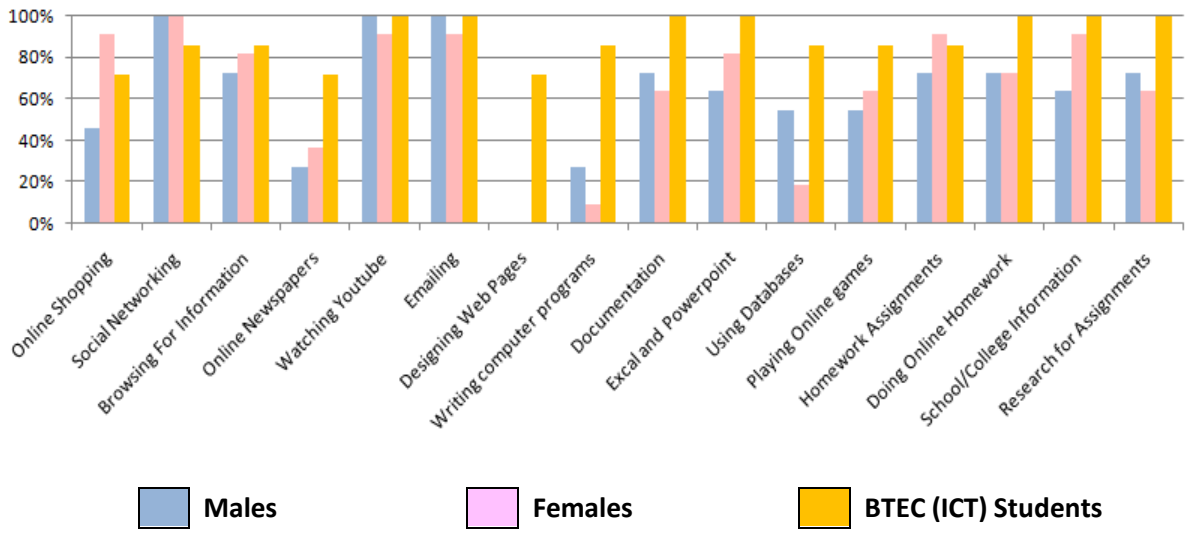
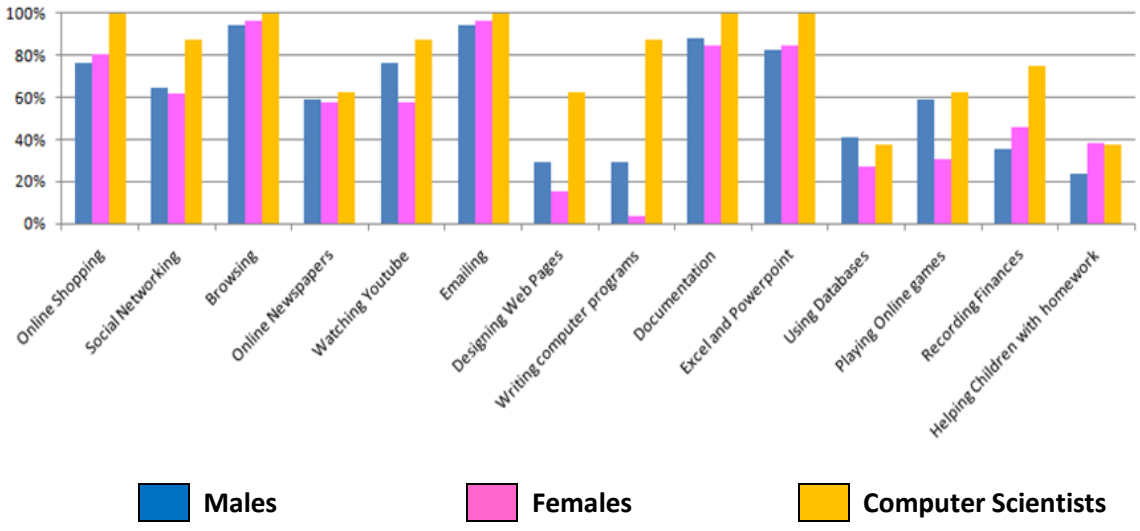


Table 2: Use of Computers among the other respondents.



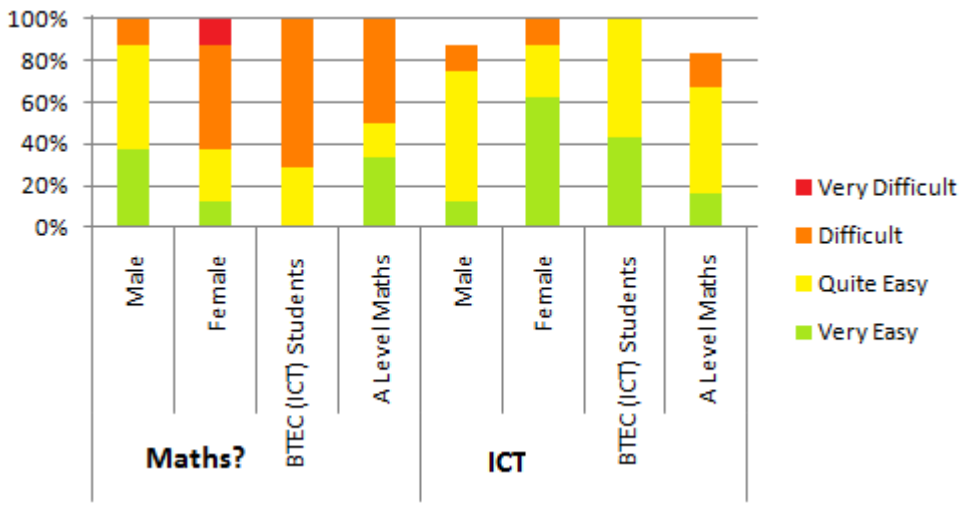
Computer Scientists are those who either work as a software engineer or who have a degree in computer science.

5.3 Confidence with Using ICT

Table 3 shows that over 60% of the female students reported that they found ICT very easy compared to only 10% of the males. This was in contrast to Maths where more males found the subject easy.

It was the students who had studied Maths at a higher level who reportedly found Maths more difficult even though they should have been more capable of doing the subject.

Table 3 How Easy Do Students Find Maths and ICT



Of the students and those under 26, more females reported that they were confident with using computers than males, although for the over 25s the reverse was the case. (Appendix D)

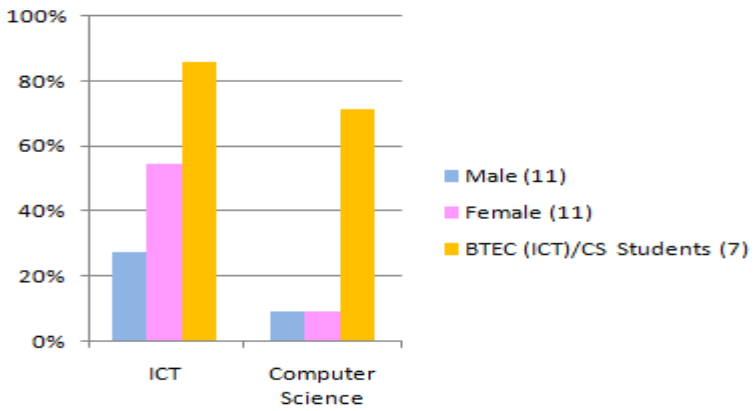
Most people were happy to use computers when others were around with just 2 females and 1 male reporting that they were not

5.4 ICT or Computer Science as a Degree Subject

Table 4 shows that of those not studying computer science, over 50% of the female students, twice as many as the number of males said that they would consider taking a degree in ICT, but only 1 male and 1 female would consider doing a degree in computer science . 3 females and 1 male stated that the reason they would not do a degree in computer science was because they didn't know anything about it (Appendix E: Table E.3).

The BTEC students all considered doing a degree in ICT, but then that was a pathway which they had already chosen by selecting that qualification.

Table 4: Percentage of students who would consider doing a degree in ICT or Computer Science



5.5 Attributes Associated with People who are good at ICT and Computer Science

People were asked to indicate which of 21 different attributes they associated with someone who is good at ICT or Computer Science and to analyse the results, the respondents have been split into the following 4 categories.

1) Teachers and PGCE students
2) Those who are not teachers but should be able to provide informed answers as they have a degree in computer science or work as a software engineer.
3) School and College Students
4) Others, who don't fall within the first 3 categories

Table 5: Top 8 attributes associated with people who are good at ICT.

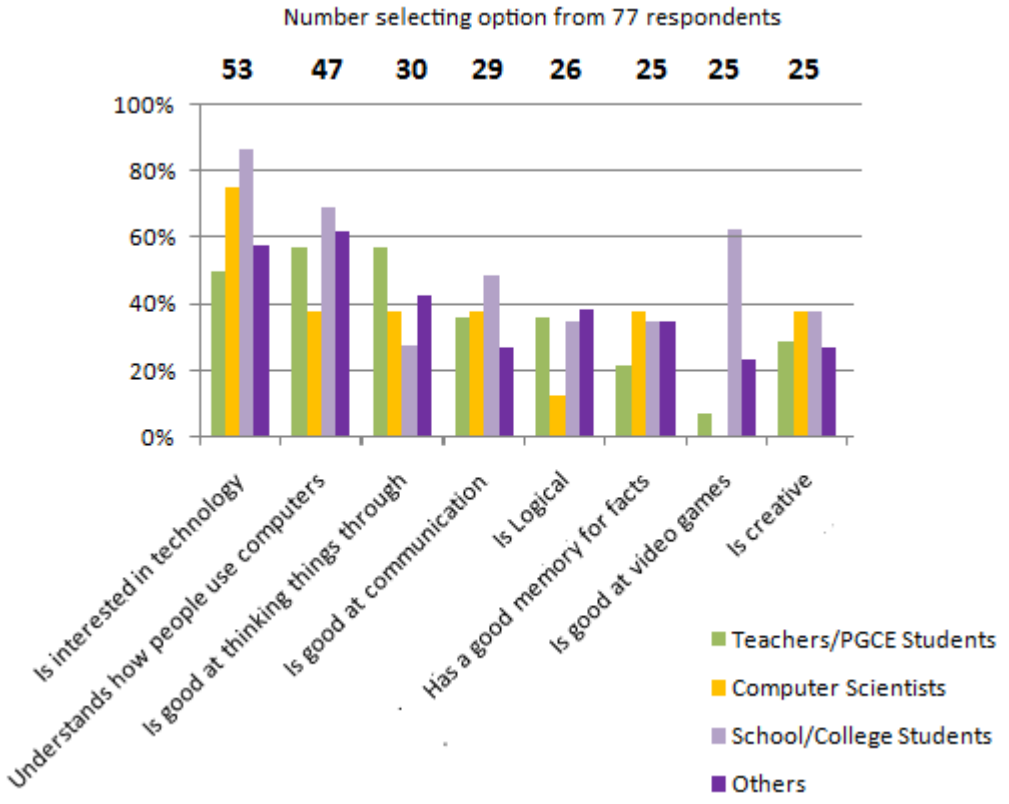
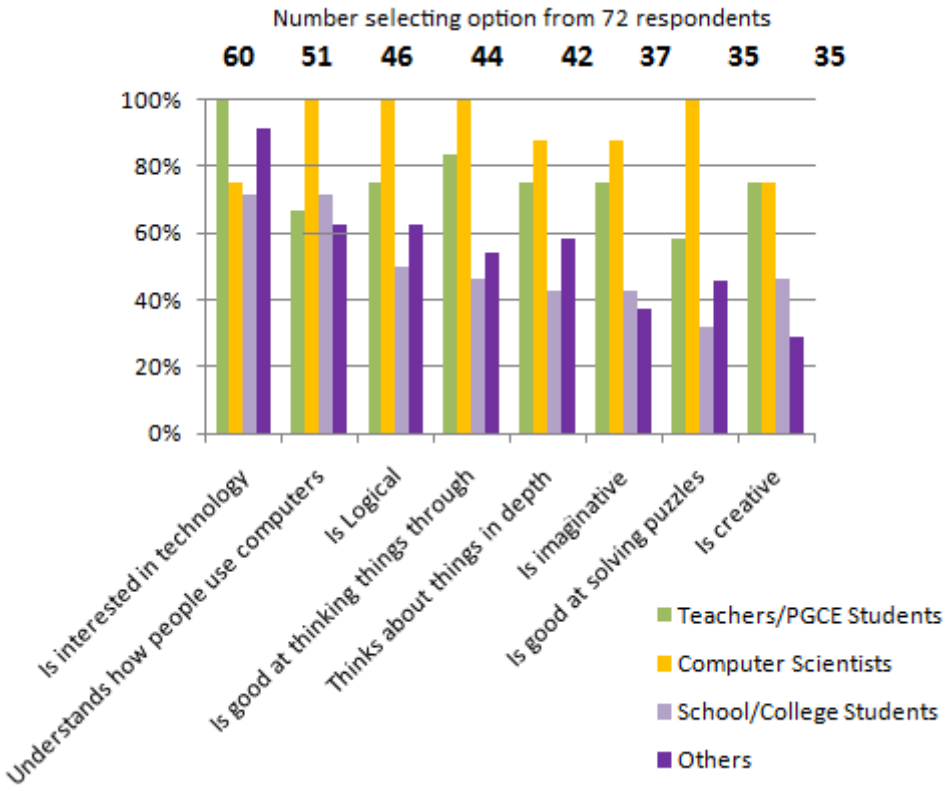


Table 6 – Top 8 attributes associates with people who are good at Computer Science.



Tables 5 and 6 show the attributes which most people associated with those that are good at ICT and Computer Science, and show a substantial consensus among the computer scientists about their own subject. Of interest, this group thought that being “logical” was a key attribute compared to only 1 out of 8 indicating the same for ICT and they did not think that being good at video games nor interested in Sci-Fi were associated attributes. Few Teachers or Computer Scientists though that being a “Geek” was an attribute compared to over 40% of everyone else. (Appendix G: Table G.2).

5.6 Attributes Associated with Males and Females

Respondents were also asked to indicate which attributes from the same list they associated with males and females (Appendix H). Tables 7 and 8 show the top responses.

Table 7: Top 7 attributes associated with males

Attribute	Total out of 59 responses
Is Interested in technology	**56**
Good at Video Games	**45**
Logical	**40**
Good at Ball Games	**39**
Good with Number	**37**
Is a Geek	**36**
Is Good At Solving Puzzles	**35**

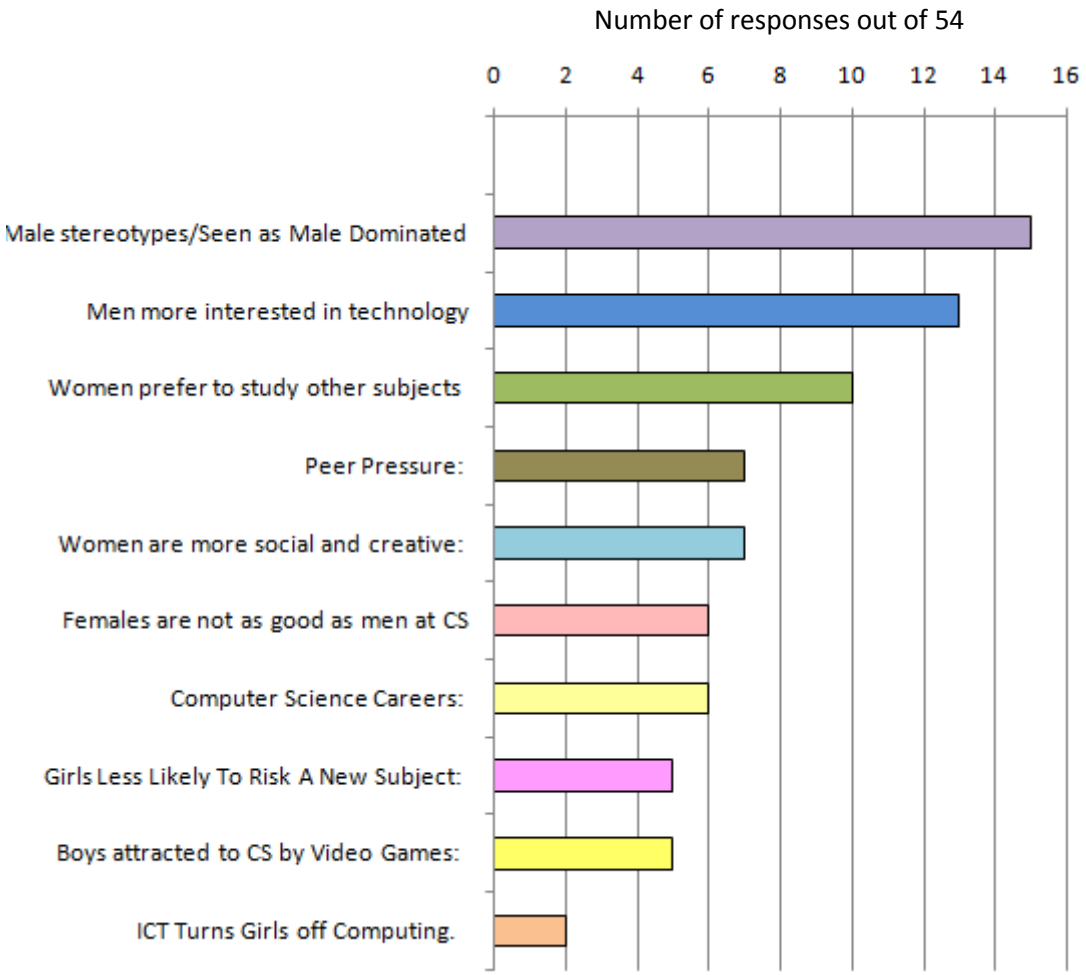
Table 8: Top 7 attributes associated with females

Attribute	Total out of 60 responses
Good At Communication	**42**
Creative	**39**
Imaginative	**38**
Social/Enjoy being around others	**37**
Good at Explaining	**32**
Enjoys being part of a team	**31**
Good memory For Facts	**28**

5.7 Why Don't Females Apply To Do Computer Science at University

Various reasons were given as to why females do not choose to study computer science as a degree subject (Appendix J) Table 9 provides a breakdown of the various reasons given.

Table 9: Reasons given why females don't do Computer Science at University



6 Analysis of Findings

6.1 A Comparison with the Reasons Suggested by the Literature Review.

A number of reasons for the gender gap were suggested by the literature review which can be compared with the findings from the primary research.

ICT turns off females

The evidence from the primary data contradicted this. It showed females use computer as much as males and that females not only found ICT easier, supported by the fact that they achieved higher at A-Level, but were also more confident with using computers (Appendices A and D). With the necessity to use computers for assignments and the increase in social networking over the past few years, it could be assumed that females are becoming increasingly comfortable with using computers.

Risk of Specialisation (Women don't know much about it)

If women are less likely to take risks, then this could be a strong contributing factor supported by the survey responses which indicated that students would often not consider doing a degree in Computer Science as they had not studied it or did not know much about it. (Appendix E: Table E.3)

It was predominantly those who were informed about Computer Science who stated that this could be a possible reason. (Appendix J: Table J.2). One response commented that because there are a lack of schools which run computer courses, judgements is then left much more to hearsay and influenced by social

grouping. This is a significant point since when people are uninformed; their perceptions are more likely to be based on cultural influences.

Stereo Types and Lack of Female Role Models

The literature review had suggested that the Geek stereotype put off females. Over a third of respondents associated Geek with being an attribute of Computer Scientists although it was mainly the older respondents who suggested this as a possible factor for putting women off computer science. People thought that Geek was a male attribute and surprisingly, about 30% of students thought it was a female attribute as well which could explain why they did not suggest it was a contributing factor to the gender gap.

The fact that the industry is seen as male dominated, was perceived to be a problem, backed up with "An interest in technology" not only being the top attribute associated with computer scientists but also the top one associated with males. However, none of these factors were given by female students as a reason they would not consider doing a degree in computer science so it could be that, as females start to use computers more, the cultural stereotypes are declining.

6.2 Other Reasons Suggested by the Primary Research

Women are more Social and Creative

Some people thought that women are not interested in computer science because they are more creative, an observation supported by 70% of respondents who thought that creativity is a female attribute. Yet computer scientists thought that

creativity and imagination were attributes associated with their subject (Appendix G: Table G.4).

A key element of Computer Science is within the design and presentation of information on the screen and looking at aspects of usability to provide the best user experience. These are elements which many women would enjoy being involved in and one of the females who took computer science as part of her degree stated that one of the appeals was that it allowed her to be creative. Most females probably don't appreciate this side of the subject.

Women prefer to be doing other things or study other subjects

10 people gave this as possible reason although the same could be said for any other subject (Appendix J: Table J.1). Some people believe that females favour the humanities and less scientific subjects, but the case for this does not extend to this study.

Similarly some people thought that other careers might be more appealing or don't know enough about the career options. Software Engineering companies often offer flexible working hours and home working options which would be on a benefit to mothers. However, technology moves on fast which makes taking a career break difficult.

Boys motivated to do Computer Science by Video Games.

One of the motivation factors for males to take up computer science is though their interest in video games. It was one of the top attribute associated with males and one of those least associated with females (Appendix H)

The contribution of this factor towards the gender gap was suggested by over 50% of those who had studied computer science at university, probably informed by those they had met while doing so. A female CS student stated that she liked video games and that there were now more games being aimed at girls (Appendix J: Table J.2)

This could be supported by the responses from the question about whether people played online games. Although overall more males than females said they played online games, of the students who were not studying for a BTEC, more females said that they played them. (Appendix F Table F.1)

Yet, even though computer scientists saw this as a contributing factor, none of them thought that being good at video games was an attribute of someone who was good at computer science. (Appendix G: Table G.2)

Further insight into the influence of video games could have been established by asking the BTEC (IT Practitioners) students for their motivation into taking that qualification.

6.3 Evaluation of the Research Process

Literature Review

The initial review of the literature was informative and gave guidance towards putting together the questionnaire. However the rate at which technology has progressed and people's experience of it has changed significantly over the past few decades. This meant that some of the books written earlier in the decade will have been looking at a cultural environment which has moved on.

Questionnaire Responses

Receiving 80 responses from a good cross section of the genders, students, teachers, computer scientists and others mean that the results have been reasonably reliable. The response rate was very high when questionnaire were handed out but just 30% when using email.

Some respondents were discouraged from completing the questionnaire as they found the questions concerning qualifications irrelevant to them and believed that the rest of the questionnaire would be too. This could have contributed to a higher rate of email responses from those with an academic background. A Modification to the questionnaire could have helped overcome this bias.

Further Investigation

After analysing the data, further types of question have arisen which could be added used to extend this research. These relate to;

1) The degree to which teachers understand the differences between ICT and computer sciences.
2) The perception of the creative aspects of computer science including web page design.
3) The reasons why students enrol onto vocational IT courses.

Data also emerged from the primary research with respect to the gender gap within the study of Mathematic which had not been used. This could lead to further research into the gender gap with respect to the relationship between Mathematics and Computer Science.

7 Conclusion

Computers are used extensively in today's society and to ensure that people acquire the skills they need. The use of ICT is now a statutory curriculum requirement. With the range of ICT qualifications being offered at all levels and the use of ICT in all subjects, students can gain an insight into this subject without having to specialise in it.

ICT may have been perceived as a male subject but it is now becoming increasingly popular with females. Social Networking and Internet shopping appeal to females who are becoming increasingly confident with computers. This trend can be observed by the statistics which show that females are outperforming males at the ICT A-Level. Yet, in contrast, there has been an increase in the gender gap over the past decades of those choosing to study computer science at university and females now represent just 12% of those choosing to do so.

The curriculum does not encourage students to encounter computer science. There has been a decline in the uptake of Computer Science at A-Level, potentially because educational establishments are no longer offering it, and students can often only study this subject by specialising in qualifications such as the BTEC ICT, or as a university degree. Students, especially females, who have no previous experience of computer science, may be reticent to risk doing this.

If females have little understanding of computer science, they will be more inclined to rely on cultural perceptions to inform them. From this, females will often view the subject to be male dominated, geeky and very technical, lacking the attributes

which might attract them. In contrast, males may not only view it as a subject which in nature is suited to them, but also provides them with an opportunity to be part of an industry which develops the video games which many of them enjoy playing.

The reality is that many areas of computer science require a degree of imagination and creativity, which are attributes frequently associated with females. In particular in the design and creation of web applications where women may also be more perceptive as to their usability and have a better insight into how women may be using them.

If the computer industry is to address the current gender gap, then it needs to overcome the obstacles which deter females from enrolling in computer science qualifications. To address the issue, this research concludes with the following recommendations:

1) Teachers should be made aware of the differences between ICT and Computer Science.

2) Individual subjects could incorporate a degree of computer science, e.g. through the creation of web pages or using related concepts such as flow diagrams.
3) There could be web design qualifications which students can opt to take alongside their other qualifications

4) There could be specific events to inform students about computer science and encourage them to consider it as a subject they may want to study.

(Word Count : 5487)