Females in Computing: Understanding Stereotypes through Collaborative Picturing

Abstract

This study investigates attitudes and perceived stereotypes that children have towards female computer scientists. Research was conducted within 2 high schools in Scotland across 7 workshops including 96 participants. Stereotype patterns and social expectations were identified giving insight into gendered world views. Data was derived through picturing. Collaborative picture drawing, as a means to investigate multiple opinions, is a powerful activity that has the capacity to break down barriers of education, language and culture. By use of content analysis on 24 workshop pictures three key areas were identified as significant when determining attitudes towards computing as a career choice for females; gender stereotypes, role models, and media influence. The conclusion determines there are stereotype misconceptions regarding physical appearance, personality type, and digital ability projected onto young females. These can influence their academic decisions resulting in poor uptake of computing science as a career choice. We determine that Computing Science is seen as a male gendered subject with females who select to work or study in this field having low self-worth, a sense of being different, a sense of being atypical, and a sense of being unattractive We further determine that positive role models and positive gender balanced media influences can broaden identities in computing.

1. Introduction

The purpose of this study is to investigate beliefs attitudes and perceived stereotypes that children have towards female computer scientists. Despite various interventions, over many decades, the discipline of computing science (CS) still appears to be unattractive to females. In this study we investigate the perceived stereotypes associated with females in CS from the viewpoint of adolescent boys and girls. This study is important in terms of problem appreciation from a specific group of stakeholders, namely adolescent children. Before we can make change to improve attractiveness and retentions figures for females in CS we have to understand what the problem is, why the problem exists, and who or what perpetuates the issues. In this study we ask adolescent children their views on females in computing and determine if there is a difference between boys and girls. Using visuals as a medium for knowledge discovery we seek to identify perceived physical appearance, perceived personality type, and perceived digital abilities that are associated with females in CS.

Females are seriously underrepresented in STEM subjects (Science, Technology, Engineering, and Mathematics). This is commonly known as the leaky pipeline describing the path and dropout rate from school to work of females in STEM. It is described as leaky due to the numbers of women who 'fall out of the pipeline' (Varma & Hahn, 2008) by dropping out of STEM fields at differing stages of their careers. Researchers have sought to find various issues within secondary school education that could contribute to the dwindling numbers of women. For example, Han (2016) highlighted that when asked about their future, male secondary school pupils expected to enter STEM subject based careers, whereas females expected to enter industries such as healthcare and life sciences. Shoffner (2015)

suggests this is due to a decrease in self-esteem and a fear of failure in STEM subjects as a woman progresses through secondary school. Indeed, this view of a lack of confidence has been highlighted as a key issue by numerous researchers (Meelissen & Drent, 2008; Stoilescu & Egodawatte, 2010; Vekiri, 2013). Having a female teacher provides female students with a role model, and can help the retention along the pipeline (Friend, 2015; Beyer, 2014). Gendered messages can shape school pupils' opinions (Shapiro, et al., 2015), and under-represent females within the field (Herman, 2015; Friend, 2015; Beyer, 2014). Classroom environments whereby stereotypical images and symbols are displayed can also be a deterrent, as it can lead to dissuasion and a general lack of belonging within the subject (Cheryan, et al., 2011). The reason this is more pertinent to females, as suggested by Vitores & Gil-Juárez (2015) is due to the fact that these potentially harmful images and stereotypes seem to have a greater effect on females than males.

Many researchers have looked specifically at the STEM field of computing Science (CS) and the dearth of females. Lovegrove & Hall (1991) suggested that as children, boys tend to take a more hands on approach to technology, whereas girls tended to be cautious, and afraid to make mistakes in front of their peers. Ogan, et al (2006) additionally stated that males tend to learn computing related skills independently, in the home, whereas females tended to learn in organisations such as schools, potentially leading to males receiving better grades if they are learning at a younger age (Denner, et al., 2014). This perception of males performing better in computer science is a negative stereotype, despite the fact that the differences in performance are negligible (Beyer, 1999). Kermarrec (2014) recognised that school children are at the age where they are most likely to be influenced by stereotypes, and by the time they reach University, it is harder to change views that have been formed. Goode et al (2006) suggested some reasons why and how high school female students are, or are not, drawn into the field of CS. The discovered that there were few learning opportunities existing at high school level, pre-set notions of relevance play a key role in influencing choice, and a limited and narrow presentation is purported on what CS is and what computer scientists do. Goode et al further suggest that female students who do take CS have negative experiences in classroom settings, where greater male technology experience and female isolation are part of the cultural setting.

Papastergiou (2007) investigated Greek high school students' intentions and motivation towards and against pursuing studies in CS. She found that girls are less likely to pursue CS due to extrinsic reasons rather than personal interest. Extrinsic reasons were suggested to be lack of opportunities for early familiarization with computing in the home and scholastic environments involving teaching and encouragement. Meelissen & Drent (2008) state that there are non-academic factors which affect an individual's view on computing such as digital availability in the home, parental influence, the overall gender bias towards men in computing, and the general technical skills. Vekiri & Chronaki (2008) further this by suggesting any gender differences that may exist are through socialisations between an individual and their family and peers. Their studies, measuring perceived parental support, showed that boys tended to use computers more in their daily activities than girls that were questioned in a survey, despite equal accessibility to computers for both genders. However, they found primarily that parental encouragement is a greater influencer to their child's self-confidence than computer based activities (Ibid.).

Over the past few decades, various solutions to the 'leaky pipeline' have been suggested each with varying levels of success (Tech Partnership, 2016). Intervention programmes showcasing to secondary school girls the various different careers available to them have had "limited effects" in terms of its success (Lang, et al., 2015). It has been highlighted that earlier intervention methods may be necessary to help improve numbers of women in CS and later representation (Klawe, et al., 2009). Klawe, et al suggest that potentially, efforts at a secondary school level, may be too late to help

improve the situation and encourage more girls into CS related subjects. However, Alvarado & Judson (2014) highlight the success of conferences with college students, helping them to decide whether or not to major in CS related subjects. Vitores and Gil-Juarez (2015) suggest the problem exists with the masculine culture that surrounds computing, education and work and that computing is a "chilly environment" where women need metaphoric "sweaters" to survive.

2 Stereotypes in Computing

Stereotypes are a key detrimental gender issue that affects many women who wish to enter the field of CS. As with many other fields, the stereotypes pertaining to technology are integrally linked with much wider, cultural gender stereotypes (Perry & Cannon, 1968). Best, et al. (1977) suggests that the archetypal stereotypes of men displayed a picture of one who was "ambitious, rational, and independent, as well as egotistical, coarse, and unemotional." A woman is described as being "affectionate, sensitive, and sociable, as well as frivolous, high-strung, and submissive." When these male stereotypes are compared to the characteristics relating to scientists, parallels can be identified. Namely, a scientist is often seen to be vastly independent from those around them, with a relatively low need for social interactions, and an element of emotional withdrawal (Rossi, 1965). This conflicts with the generic female stereotype, whereby it was identified that females tended to be sociable, and concerning (Best, et al., 1977). However, despite the fact that these attitudes existed a generation ago, these gender stereotypes still play a large part in contemporary organisations and institutions today. Stereotypes identified by Best, et al. (1977) are mirrored twenty years later by Chodorow (1998), who likewise describes men to be independent, unemotional, and rational. Current attitudes and stereotypes towards computing related courses are also similar to what they were half a century ago. A lack of social skills and a need to be independent is still a stereotype of a typical computer scientist in the contemporary environment (Cheryan, et al., 2013; Master, et al., 2015; Wong 2017). Due to these parallels, CS is still seen therefore, as a stereotypically male subject (Cheryan, et al., 2013) as it clashes with what is to be perceived as the non-digital female gender role (Cheryan, et al., 2009; Wong, 2017). Some researchers suggest the role that media plays in perpetuating the stereotype, and the overrepresentation of males in the media and the discipline (Cheryan, et al., 2013; Mercier, et al., 2006). Media representation enforces the stereotypes of a computer scientist in various Western television programmes and films, such as Office Space, Bedazzled and The Big Bang Theory (Mercier, et al., 2006). Characters in these films and shows portray the stereotype of the antisocial, unattractive, technology focused, and geeky male scientists. These films and shows are impactful for the development of stereotypes, as they appeal to a younger audience, some of whom have these shows and films as their only source of what scientists may look and act like (Cheryan, et al., 2013). There have been attempts to combat this media underrepresentation, to eradicate these stereotypes, yet they still persist in today's society (Tech Partnership, 2016, p12-24) (Wong, 2016).

This study investigates attitudes and perceived stereotypes that children have towards female computer scientists. Research was conducted within 2 high schools in Scotland with 96 children participants. We focus interest on stereotype patterns and social expectations of commonality. Rather than asking the children to tell us their answers in words, such as the Greek high school study by Papastergiou (2007), we asked school children to draw their ideas, narratives and concerns in pictures. We use this pictorial method because we recognise the value of groups developing visual narratives (Bell et al, 2016) through thinking together and sharing ideas. Further, visual metaphors can be a way to express thoughts and opinions that might be difficult to articulate in words. The research questions this research will investigate are:

Research Questions

1. **What do children in selected Scottish High Schools think about females in computing?**
2. **Do boys and girls differ in their teenage stereotypes regarding women as computer scientists?**

3. Methodology

This investigation looks at why there are so few women in computing from the perspective of the Scottish high school child. We asked 96 children between the ages of 13-17 why they believe there are so few girls selecting Computing Science (CS) as a career choice. All 96 were either taking computing as a compulsory course in year 3 or as a subject choice in years 4, 5 and 6. 24 groups in 7 workshops drew collaborative pictures regarding the question above. Groups and their pictures were coded noting gender, year group and group size. Group numbers ranged from 3-5 participants with mixed gender groups being encouraged by the facilitator. In total there were 3 groups of girls, 4 groups of all mixed gender and 17 groups of all boys. In total there were 27 girls and 69 boys. There are numerous reasons for the high boy participant rate however the primary explanation is because there were more boys studying computing as a subject choice than there were girls. This ongoing gender divide is acknowledged with statistical evidence in the 2016 BCS Tech partnership report (Tech Partnership, 2016, p12-24)

Two High schools in Scotland were selected for this study. They were chosen as they presented a different environment and locations within Scotland. One school was a highly populated school in the centre of a city and another was a school in a rural location in Scotland with small numbers. Each school hosted workshops which were facilitated by the same facilitator and appropriate ethical procedure and consent were applied throughout the project with all participants being anonymised. Focus groups discussions were employed alongside a collaborative drawing technique called the rich picture (RP).

The RP is a familiar method used in computing to gather understanding about human activity for system design. The philosophical approach is one of action research with grounded theory. This theoretical framework is standardly used with RP research as the approach allows iteration of data interpretation and flexibility with data collection and analysis methods. The RP assists the exploration of different world views within a complex situation. The RP is a physical picture drawn by a variety of hands which encourages discussion and debate for groups and allows them to arrive at an agreed understanding. This makes it a powerful device in participatory processes. RPs consist of a set of entities we call icons (Bell et al, 2016). Icons can represent objects or processes such as action or emotion. The RP is not rule bound in facilitation, form or content and creators are encouraged to add their own subjective interpretation to the picture. The RP expresses, via a symbolic language, and aids group understanding by initiating problem investigation in a permissive environment. RPs have the capability to recreate in the present what has happened in the past, represent the now whilst offering insight into the future. The RP can add extra dimension and a level of truthful tacit understanding that might not be available through other methods of group investigation. The collaboratively drawn RP offers a group consensus rather than an individual opinion. Academic literature is replete with examples of the RP being used in situations away from its roots in system design from nursing (Ballard, 2007), social care (Fougner & Habib, 2008), internet security (Just &

Berg, 2017), construction (Mazijoglou & Scrivener, 1998), creativity (Proctor, 1995) landscape visualisation (Boedhihartono, 2012) and engineering (Sutrisna & Barrett, 2007) to name just a few of the instances where they emerge.

Workshop process:

Stage and Activity
1. Consent and group formulation
2. Introduction
3. Rich picture drawing
4. Group explanations of the RP

Table 1 Workshop stages

Students participated in one of the 7, identically run, 4 stage workshops. Table 1 shows the stages of each workshop. In stage 1, the participants read a short project description and sign a consent form. Participants were sorted, by the facilitator, into small groups of 3/4/5; group size depending on workshop attendance. In stage 1 the facilitator gathered information on year group, age, and gender. In stage 2 the facilitator (same person for all 7 workshops) introduced the purpose of the workshop and presented the research questions. Participants were asked to respond to the questions by drawing their answers in pictures on a single large flip chart sized paper with a variety of coloured pens. Figure 1 is a copy of the presentation slide showing the questions that participants were asked to consider prior to drawing.

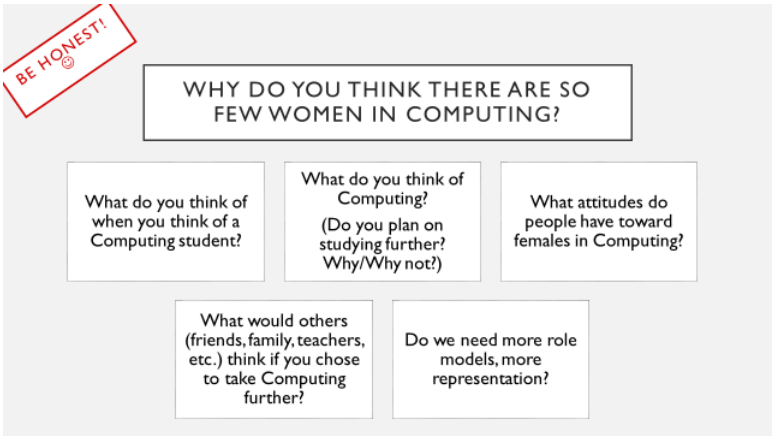

Figure 1 Instructions to participants

In stage 3 each group drew their collaborative RP on the single sheet of paper. Examples of two of the group RPs is seen in figures 2 and 3. It is worth noting that a RP is drawn by many hands accessing the paper from different angles thus, to read the picture, one must rotate the page. In stage 4 the facilitator asked all groups to gather beside their RP, which was hung on the wall beside them. Each group discussed what they drew and why. Stage 4 was facilitator lead with participants being encouraged to share their stories and expand upon their drawings with words. The discussions were audio recorded and later transcribed.

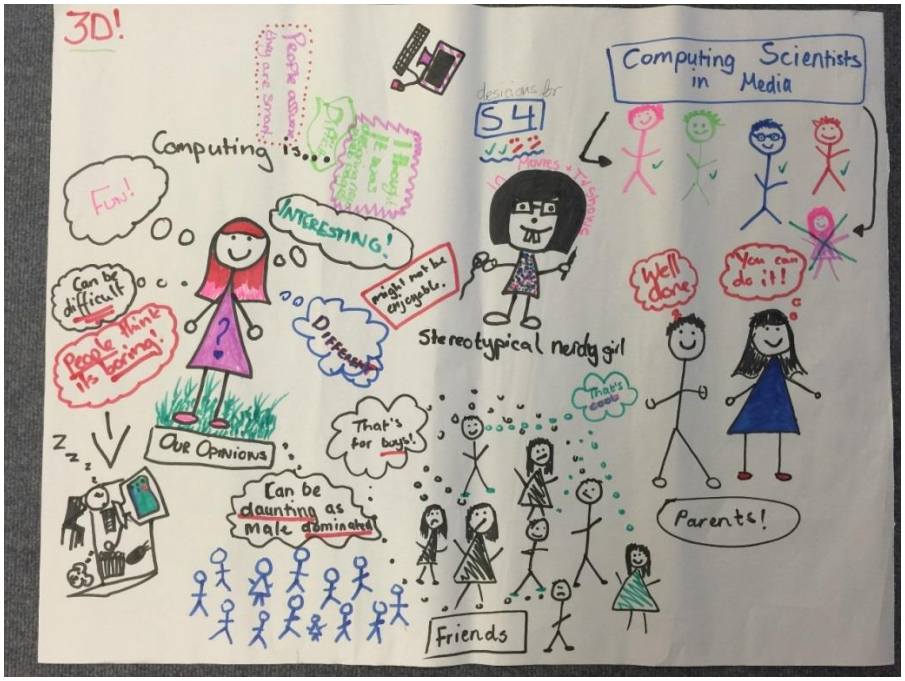

Figure 2 RP drawn by 4 female participants

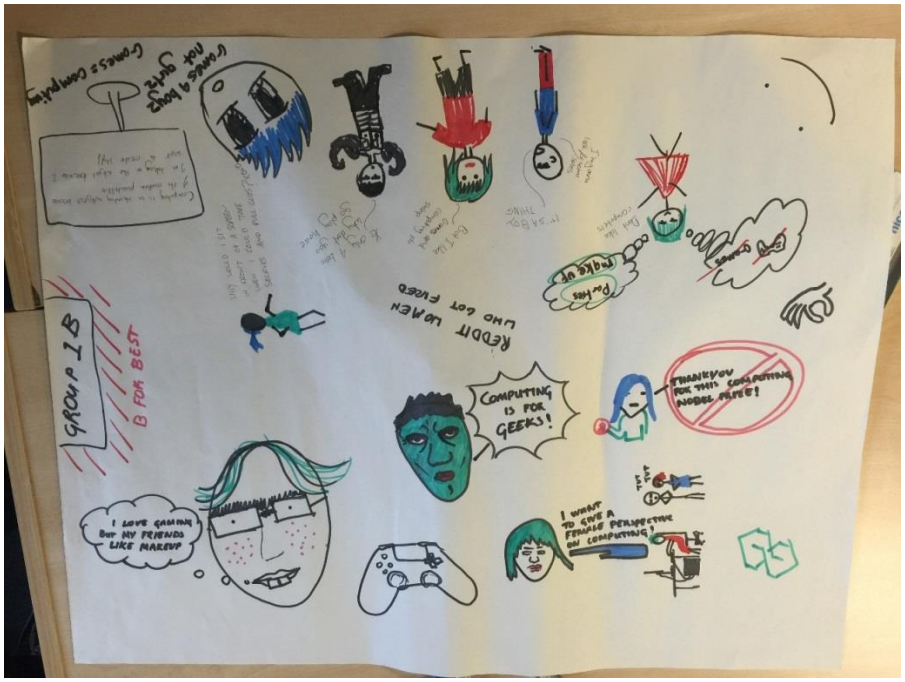

Figure 3 RP drawn by 3 male participants

Data Analysis

Twenty four RPs within 7 workshops were coded and categorised and the corresponding transcripts were analysed using content analysis. Content analysis can be applied to any type of information, not just textual. Bell et al (2016) propose that RPs can be analysed in order to tell us about the dynamics and mind-set of those composing the RP. Content analysis is widely used in the field of social science and this research proposes to explore similarities and differences between the RPs and common elements across each group. All groups drew in pictures with the exception of one group who preferred text. Some RPs has ambiguous imagery that was not immediately understood to be relevant to the question. For example one group used images of dinosaurs throughout their RP. Whilst not

immediately understanding what this was to represent, in a subsequent discussion whereby participants were discussed what they drew, the group explained that the dinosaurs referred to the film, '*Jurassic Park'*. They stated that within this film, there is a female character that stood out to them as being a good example of representation of a female in CS. Likewise, other aspects were ambiguous in other RPs that were explained to be relevant to the questions in the subsequent discussions.

Three coders analysed the pictures and transcripts. The coders firstly transcribed the stage 4 group discussions. They then individually assessed each picture for initial understanding and inter coder reliability (Lombard et al, 2002) before matching with the other coding group members. Coders adopted a grounded theory approach (Glaser, 1967) with inductive content analysis (Lombard 2002). Using colour coded stickers and a numbering system the coders analysed every RP in great detail. The transcripts from every group were coded, numbered and matched against the corresponding picture icons in the RPs. All RPs were coded using the same system with three themes being identified as repeating common occurrences across the majority of RPs. The three themes are gender stereotypes in CS, role models, and media influence.

4. Results

4.1 Gender stereotypes in CS

The predominant theme that arose from RPs was the image of a stereotypical computer scientist. With the exception of one group, all groups visualised their understanding of a computer scientist. Children drew both male and female computer scientists with repeating similar features. Please note that children were given a selection of coloured pens and markers and were free to use colour in their pictures. An example summary of some, not all, of these images is provided in Figure 4. All visualisations were of white caucasion skin colour. Common features include the use of glasses (22 of the 23 RPs – frequently square shaped), red hair (14 of the 23 RPs), green hair (12 of the 23 RPs), spots or freckles (16 of the 23 RPs). Descriptors were used to help highlight these characteristics. 11 of the 23 RPs labelled these images as either "nerds", "geek", or "lazy". In 19 of the 24 RPs, including the all-girl groups, children indicated that CS is a masculine subject. In the after picture discussion, one all-girl group spoke of gendered disciplines "*girls are considered not being able to do computing because they are a girl. They should focus more on beauty, or on like childcare. And boys are told they should focus more on computing or building or manly stuff*". Another all-male group stated "*most girls go into care and health*". A mixed gender groups said "*a lot of guys are quite sexist towards women, saying 'Oh you're a girl, you shouldn't do this, you should do more girly stuff'. When guys are doing computing, they're considered smart, but when a girl does it, she's not considered as smart… she's considered that she can't do anything academic*". Several RPs highlight confidence as being a contributing factor for girls not choosing CS. One group (figure 5) drew a female crossed out on their RP, with and arrow pointing to it saying "*not as good at computing as men*". Another group stated "*girls can't/aren't good at it [CS]*" and drew a male figure saying that females were "*too dumb*", whilst another group continued this vein saying that to study CS you "*must be smart*".

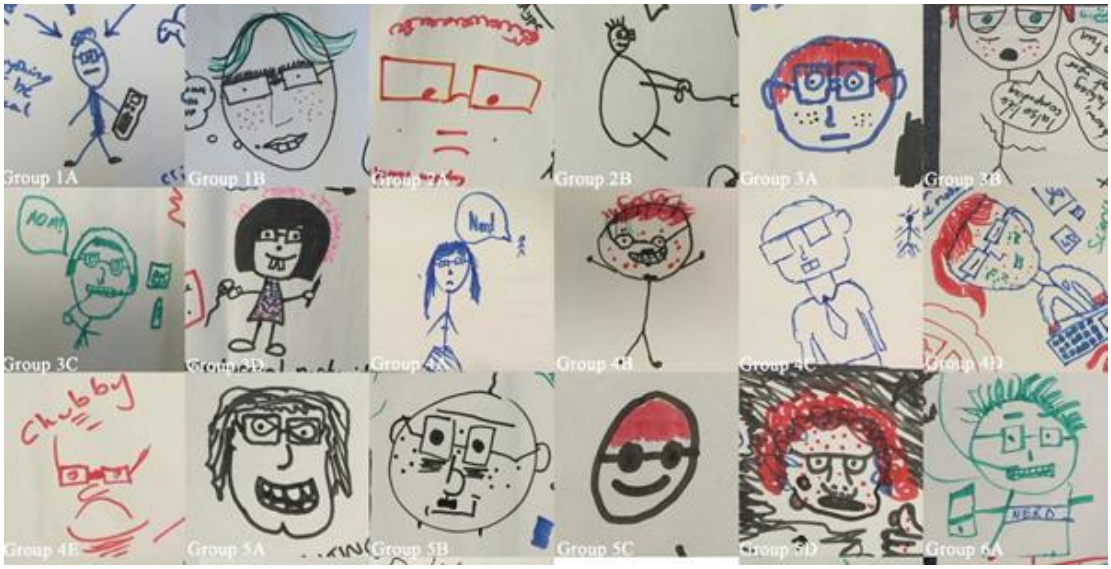

Figure 4 Images of a stereotypical computer scientist

The stereotypical imagery that occurred throughout the RPs indicated that girls are more conscious of their self-image. Upon analysing the transcription of the discussions many of the groups (both boy and girl groups) showed girls to be interested in makeup and fashion. These groups were of an opinion that the stereotypical image of the computer scientist was incompatible with that of their stereotypical image of a female. RPs showed that if girls were interested in computing, they must conform to the stereotypical image of a computer scientist. A five participant girl group stated "*girls don't really like go on computers a lot unlike boys. They are more into like makeup and stuff and they're not really like on computers… the stereotype of girls is like makeup.*" Furthermore, they added that "*people who are like on computers and things like that, it's kind of said that they don't have a social life, and girls maintain a social life.*" However, when asked if they believed that a woman can be interested in computing and still maintain and active social life, they unanimously agreed.

Figure 5 An all girl group depicting their belief that females are not good a computing.

Six of the groups who participated in the study drew, wrote, or spoke about beauty or beauty products. Of these, two groups consisted wholly of girls and the other groups were mixed gender groups. The manner in which the girl pupils spoke about beauty and beauty products had age related contrast. The younger of the two girl groups (aged 13/14), drew various symbols and named multiple brands associated with beauty. The pupils expressed that females are expected to enjoy using beauty products and that this is linked to why not as many females practice computing stating "*Girls, like, don't really, like, go on computers a lot unlike boys. They're more into, like, make-up and stuff.*" The older all girl group (aged 16/17) expressed annoyance and frustration when speaking about the expectation of them to direct their attention to beauty. One pupil identified that "*most girls are considered not able to do computing because they're a girl, they need to focus more on beauty or, like, childcare.*" The older female group (aged 15/16/17) also expressed frustration with supposed

career expectations such as caring or teaching professions however they did not state where or who these expectations are coming from. Future expectations for females were drawn by 11 groups (group participants being both girl, boy, and mixed) with the repeating themes being; expectation to be at home, have children, be a carer/teacher and peer pressure to conform to 'normal'. One girl group stated, "*Boys are told they should focus more on, like, computing or building or more manly stuff*". Another all boy group noted the lack of females in senior management roles"*Usually the head of big companies are male, and that's, like, the face of the company, so that, puts people off, women off*"

4.2 Gaming

An issue that arose in 15 RPs (both boy, girl and mixed groups), that only once surfaced within our literature review (Goode et al , 2006), was the idea that the CS equates with gaming – and the belief that women do not game so cannot be computer scientists. There was a strong theme from the boy groups that computing is strongly correlated with game design and game programming. However, within the three all girl groups gaming was only once visualised within their RPS with a drawing of a male computer scientist holding a gaming console controller. This is in comparison to the male group RPs that drew lots of gaming related images with comments such as; "*guys like to game more than girls*" and "*computer science is used for making games and gamers tend to be guys*" and "*only guys play video games*". It should be noted that playing computer/ video games has no direct correlation to theory, experimentation, and engineering that form the basis for the design and use of computers. Unless specifically designed for computational education there are few games that apply abstraction, algorithmic thinking, pattern recognition and problem solving which are the basic principles of computing science.

4.3 Role models

Children highlighted in 13 of the 24 RPs the low number of female role models in the CS industry in comparison to their male counterparts, or at least a limited awareness of such. Of these thirteen RPs; this included 2 of the 3 girl groups, 3 of the 4 mixed groups and 8 of the 17 boy groups. Within the RPs, female role models in CS were depicted both positively and negatively. Many groups (17 of 23 RPs) highlighted teachers to be a positive role model to encourage them to take computing. A girl in Group one group stated "*in this school, I think all the teachers that do computing subjects are females*". Some groups struggled to suggest positive role models "we *can't think of any female game designers or other role models*". Whilst others thought that "*there should be more female role models to encourage other woman to join computing*". Many groups (14 of 23 RPs) indicated there were some strong female role models on TV and in magazines however very few on social media. One group considered a non-stereotypical character within the film "*Jurassic Park*" to be a good role model, and that "*there should be more done to include characters such as this one*". This all boy group is interesting as they present a high level of awareness regarding CS gender stereotypes in popular culture. The boys in this group were all in S6 classes and thus likely to be aged either 16 or 17. Different genders identify with different world views however in this study age and maturity in adolescence showed deep contrast in opinion. It does seem that the younger the age group the more likely the opinions will be negative towards females in CS. In this study, the negativity is evident in young adolescents of both sexes.

4.4 Media influence

Media was discussed in 19 of the 24 RPs with predominance concerning the under representation of positive female CS people. In fact, all of the girl groups, and the mixed groups identified this as an issue, as well as 71% of the boy groups (12 of 17).

There are two areas that namely came up within this particular theme. The first being the lack of representation of females within CS in media, and the second being that if there is representation then

it usually fits with the stereotypical CS image as defined in this study, ie, nerds and geeks who have glasses, freckles, and often red hair.
The media representation of physical beauty with females who work and study in CS has been interpreted as conflicting by two groups. One group believe the manner in which women are represented in TV and films is "*not an average perso*n" and, is something more unattainable, "*they're kind of, super model*". Conversely, another group perceived the way females in CS are shown by the media to be "*quite hideous*", "*Like, really fat with lots of spots all over their face, with glasses, and stuff*". From this study we determine that positive role models and non-stereotyped and positive gender balanced media influences can broaden identities in computing.

5. Conclusion

Despite evidence of numerous initiatives (Vitores & Gil-Juárez, 2015) designed to elevate the status of CS as a career choice amongst females in the UK , the data from government sources (Tech Partnership, 2016) indicate that little has changed when looking at previous years. CS still appears to be a relatively unattractive study or career choice(Tech Partnership, 2016) (Papastergiou ,2007) (Goode et al ,2006). Our research studies the discipline of CS through the eyes of children providing unique insight into their thoughts beliefs, and understandings. Through the use of visuals and focus groups we have gathered picture representations and vocal quotes to show the problem situation from a child perspective. One could argue that we could have asked, in focus groups, interviews or questionnaires', the children rather than getting them to draw in pictures. However although this might have yielded some interesting results (see, Papastergiou, 2007) we wanted to appreciate a visual understanding of the problem situation and perhaps evidence tacit, perhaps unspoken, insight on the issue

Our research questions ask "What do children in selected Scottish High Schools think about females in computing? and Do boys and girls differ in their teenage steriotypes regarding women as computer scientists? In providing a visual opportunity to share narratives we see that children indicate their understanding of CS being a predominantly male dominated industry. A sentiment repeatedly suggested was both gendered and specific regarding appearance "*when I think of a computer scientist, I would immediately think of a man and he looks like a geek, and he's got the glasses, a tight shirt and tie*". Children further indicated that they attain such stereotypes mainly from their peers but also from the media and predominantly through television programmes as well as family and school environments. The primary issues children highlight when asked about computing as a female career choice are:

- A gendered physical appearance associated with females in CS
- A lack of awareness of role models in the field
- Limited peer encouragement towards a career in CS
- An association of gaming and CS with the assumption that gaming is for boys and therefore girls cannot have computing careers
- The gendered view of CS as being a male subject.

Within the 24 groups involved, 23 highlighted images of what they perceived to be a stereotypical computer scientist (a selection shown in Figure 4). Computer scientists were described by children as

being "*nerd*", "*geek*", and "*smart*". Boys tended to use these expressions to describe male computer scientists whereas girls preferred to indicate intelligence with the word "*smart*" and use less terms such as "*nerd*", "*geek*". The repeating images the children drew depicted similar characteristics between both male and female computer scientists. For example, 96% of the RPs depicted a computer scientist with glasses and two thirds of these drawings were of square shaped glasses, 70% drew freckles, and predominance to red hair was drawn in 61% of the representations of a computer scientist. Green (52%) and black (43%) coloured hair were also a popular choice by boys but less favoured by girls There was only one depiction of a blond haired computer scientist and that was drawn by a girl. Red hair is possibly a result of this being a UK research study with UK children. Red hair can have stigmatization in western society with stereotypes such as quick temper, weirdness, avoidance of the sun, and intellectuality (Heckert & Best, 1997).

We found that girls depicted females who were not computer scientists as more interested in beauty, fashion and starting a family. This belief seemed to come from their friends rather than environments such as family, school or media. Girls further viewed female computer scientists as being unable to peruse such interests and in particular not being able to have children. Several groups of girls commented on the conflict between family and career and the singularity of such a choice. This pattern creates a strange dichotomy. Computing as a career choice for females can be a source of much positive attention from role models, media, and teachers however such positive attention from adults is not as crucial to the shaping of a sense of self as is the negative reaction from peers. Boys of a younger adolescent age group (aged 13 and 14) were much more negative about CS females' worth and ability than boys who were older teenagers (aged 16/17). Our study reflects similar results with Goode et al (2006) in terms of female participation in computing science and the reasons why there are such low numbers. Goode suggests a lack of learning opportunities, negative classroom experiences with a narrow perspective on what CS is, and what a computer scientist does. In our study the children indicated that they had these beliefs from early childhood family experience and such beliefs were perpetuated throughout childhood and into adolescence by peers, media, family, and school environments. From this study the common themes of this impact included a low self-worth, a sense of being different, a sense of being at atypical, and a sense of being unattractive. Many of the images representing a computer scientist, drawn by both boys and girls showed a male scientist programing alone. Boys, seemed to accept and agree with this perceived isolation however the girls indicated that they do not wish to become a computer scientists because they enjoy the company of others and dislike being and working alone. This perceived theme of loneliness and isolation was also highlighted by Goode et al (2006). An important, and new area of interest in this study is with the misconception that gaming is directly associated with ability to become a computer scientist. Boys, mostly the younger age groups, repeatedly brought up the issues of gaming and how girls were not good at gaming. There seemed to be an absolute belief within many all boy groups that girls were '*rubbish*' at playing computer games and thus they would not and cannot become good computer scientists. Goode et al (2006 p5) also noticed this gendered issue within gaming technology, " *for a sub stream of boys, video games and hours of related tinkering and experimentation are the "hook" that gets them interested in computer science. These games, designed by males for boys are not pulling in girls to the same extent*".

Going forward, this study has identified some interesting findings regarding women in computing and stereotypes as perceived through the eyes of children. In this study we identify perceived physical appearance, perceived personality type, and perceived digital ability that are associated with females in CS. Our study has identified a contemporary visual perspective on issues that are associated with the underrepresentation of females in computing science. Boys and girls clearly do have differing

stereotype images and beliefs regarding women in computing. For both boys and girls the discipline is seen to be male driven, male oriented and not suitable for certain girl types. Boys relate computing to gaming and girls do not. Boys and girls associate CS with intelligence and isolation from peers. Girls perceive they cannot be attractive as computer scientists and also believe there is a reduced chance of having family and children in the future. These findings highlight the many and varied negative beliefs that our young people have in regard to perusing a career in CS

In this study we provide a unique visual insight into the views of these adolescents and their perceptions regarding females in computing. How we change these stereotypical perceptions is the next challenge. This study indicates that there is a need for more females in computing education and more female CS role models represented in the media. The role of parents should not be underestimated and we need to encourage families to expose both girls and boys to computer technology from early childhood. The gaming industry needs to employ more females to write games, programmes, and activities for girls. School environments, regarding technology use, need to be inclusive and encouraging to girls as well as boys. We need to change the perception of computing scientists and the work they do with emphasis on the importance of communication and team work. Most importantly, we need to change the perceived stereotype perceptions of physical appearance, personality type and digital ability to encourage more females into the industry.

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