Is there Gender Bias in Key Stage 3 Textbooks?: Content Analysis using the Gender Bias 14 (GB14) Measurement Tool

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Gender Bias, Genderness, Key Stage 3, Science Textbooks, STEM

ABBREVIATIONS

STEM – Science Technology Engineering Maths
GB14 – Gender Bias 14

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What this paper adds:

A new measurement tool – the Gender Bias 14 (GB14) is presented here. This tool has been developed and applied with the specific purpose of measuring the gender bias, or *genderness,* in Key Stage 3 science textbooks. However, the tool has been created in such a way that it will be universally applicable or adaptable to be used as a measurement tool of the *genderness* of other textbooks or resources pertinent to issues of gender awareness.

Abstract

Background: In recent times, there has been much interest in the worlds of Science, Technology, Engineering and Maths (STEM) over why a gender gap exists. The gap exists from as early as infancy and continues onwards through to secondary school where it has been shown to influence choice of A-Levels. The result of this gender gap is therefore thought to influence future career options and the longer-term career trajectory. The objective of this study was to develop an instrument that measures overall gender bias, or *genderness*, within Key Stage 3 textbooks; Textbooks that may exert an influence on an individual's choice of A-level study, and their subsequent career.

Methods: Using descriptors that reflect different aspects of *genderness*, the Gender Bias 14 (GB14) tool was developed, piloted and tested for inter-rater reliability. The tool was then used to analyse the content of Key Stage 3 textbooks for *genderness* and a *genderness score* was generated for each chapter.

Results: With high inter-rater reliability, the GB14 tool was used to analyse the content of a selected set of Key Stage 3 2014 National Curriculum science textbooks, from a single publisher, for gender bias and a *genderness* score was generated. Results have demonstrated that of the 18 chapters across these textbooks, 16 of those chapters were highly male biased. Overall, there were more male images, more male role-models, more male pronouns, more male-gendered words and more occasions where the 'status' of the male was 'improved' compared to the female measured status.

Conclusion: The GB14 analysis tool has determined that the National Curriculum textbooks for Key Stage 3 Science are very highly gendered and have a strong bias towards males which, whilst the impact has not been directly measured here, has the potential to severely disadvantage female students within the classroom. This further adds to the 'Hidden Curriculum' which reportedly influences students' future life choices (Wren, 1999; Blumberg, 2008; Michalec, 2011). The GB14 fulfils modern measurement tool requirements for content validity and provides a global score of *genderness* severity, present within textbooks.

Introduction: Around the world, girls between the ages of 5 and 14 spend 550 million hours on household chores, 160 million more hours than boys in the same age group (World Economic Forum, 2016), yet 20% of men between 25-34 believe that women's equality has gone too far (Fawcett Society, 2017).

Gender biases typically stem from the perceived mismatch between what is expected of the *typical woman* and the requirements of jobs that historically were held by men, such as professor, scientist, and investment banker. In fact, many of the historically male-dominated jobs are still held predominantly by men. For example, tenure-track jobs at research institutions are still 70-80% male (Gender Bias Project, 2017).

Young women today face a different set of challenges in advancing equality compared to previous generations. Younger women feel more empowered to stand up for their rights and more young women are university educated than in previous generations. However, pervasive gender norms and stereotypes, persistent harassment and the so-called "lad culture" are holding young women back from a fair chance to achieve their potential (Fawcett Society, 2017).

The gender gap starts young. The majority of adverts for childrens' toys are sexist and reinforce narrow and limiting gender stereotypes, according to findings released as retailers face pressure to drop gender-based marketing (Pearlman, 2016). Indeed, a study of adverts broadcast on UK television by the "Let Toys Be Toys" campaign group revealed that adverts featuring vehicles, action figures, construction sets and toy weapons featured only boys (Gander, 2015). This article in the Independent, goes on to describe how boys in the adverts were shown as active and aggressive, with the language used emphasising control, power and conflict. Meanwhile, girls appeared in adverts for dolls and toys, focused on glamour, grooming and nurturing relationships. There was a contrast in how the girls behaved when compared with the boys, as they were more passive and less active.

No country in the world has closed its gender gap. The true reality of the 21st Century is a working world which still excludes, underpays, overlooks and exploits half of its available talent - women (World Economic Forum, 2016). Gender bias in academia and industry is thriving well and where it remains unrecognised, may have potentially damaging consequences. Women the world over, face stark disparities in health, finance, education, politics, and other arenas (Smith, Choueiti and Pieper, 2016). At this micro level, gender discrimination can impede girls and women from achieving their individual aspirations; whilst at the macro level, may threaten economic growth and social progress (Seguino, 2008). In response to this threat, the United Nations (UN) championed an increase in equality for women and girls across different sectors, through its Millennium Development Goals (UN, 2015). Across the world, more girls are in school compared to 15 years ago; women now make up 41% of paid workers outside of agriculture and women have gained parliamentary representation in 174 countries over the past 20 years (UN, 2015). Greater educational attainment has accounted for about half of the economic growth in Organisation for Economic Co-operation and Development (OECD) countries in the past 50 years and this is because more girls have been brought to higher levels of education and are achieving greater gender equality in the number of years spent in education (OECD, 2012). However, greater educational equality does not guarantee equality in the workplace. High childcare costs mean that it is not economically worthwhile for women to work full-time. Workplace culture penalises women for interrupting their careers to have children; and if women continue to bear the burden of unpaid household chores, childcare and looking after ageing parents, it will be difficult for them to realise their full potential in paid work. In developing countries, if discriminatory social norms favour early marriage and limit women's access to credit, girls' significant gains in educational attainment may not lead to increased formal employment and entrepreneurship (OECD, 2012).

Women's participation in paid employment has been encouraged by United Kingdom (UK) and European Union (EU) policies aimed at reducing barriers to work caused by conflicting work and family responsibilities (Lewis, 2012). As a result there has been a marked increase in the proportion of mothers in the labour force (Scott and Clery, 2013). However, gender equality in terms of who continues to do the bulk of the household chores and the childcare has made little progress. Whilst there is a rising tide of support for gender equality (Ingelhart and Norris, 2003), on the other hand, we are in a position of incomplete revolution (Esping-Andersen, 2009). The British public sees a mismatch between depictions of gender-neutral 'adult-worker' families and the practical realities of the gender division of paid and unpaid labour, especially when children are young. We are seeing a 'structural lag' – whereby men and societal institutions (parental leave, childcare, employment and so on) have to catch-up with the realities of changing families and women's new roles (Scott and Clery, 2013).

Women in STEM: For many years now, there has much soul-searching going on in the worlds of Science, Technology, Engineering and Maths (STEM) over why women are under-represented in these career areas (Hill, Corbett and St. Rose, 2010). Engineering and science industries are a vital part of the economy, but these are threatened with a skills deficit (Roberts, 2002). School leavers and college/university graduates are not entering these fields as they are leaving education without the necessary STEM qualifications to do the jobs. The problem is highlighted in the 'It's not for people like me' report where "Britain produces 12,000 engineering graduates a year and there are currently 54,000 vacancies" (MacDonald, 2014, p. 4). This shortage of engineers is impacting UK industry, and the consequences will be higher project costs, delays to projects, damage to the UK economy (Atkins, 2015).

Identifying and understanding distinct patterns of gender bias exposure, is a first step towards ensuring that *genderness* biases do not derail an individual's career. One method is to look at the influence of early choices. Choices made in young adulthood, such as GCSE or A Level options. Gender bias in STEM education is not a new topic for discussion. The Institute of Physics (2013a) reported a significant gap between how many boys and girls continue their education in the sciences, with boys uptake being four times greater than girls, particularly for A-Level physics. Schools are not providing an equitable education for all (Murphy and Whitelegg, 2006). Evidence has shown that there are many critical factors, not just in schools, that affect female attitudes towards science subjects in particular, causing the shortfall of numbers at A-level. These range from parental influence (Women in Science, Technology, Engineering and Mathematics, 2015), family science capital (Archer *et al*., 2012), teachers' attitudes and school culture (The Institute of Physics, 2013a).

The Roberts' Review (2002) identified that women, in particular, were underrepresented in maths, engineering, and the physical sciences. The review suggested that experiences at a school level, such as the shortage of specialist teachers in maths and science, the uninspiring methods used to teach the subjects and the careers advice given to students were the root cause. The Roberts' Review (2002) recommended that intervention at the school level is required. Since 2002, there has been significant investment in STEM education from government, charities, subject associations, learned societies and industry. Many different organisations have been working to engage young people in the opportunities that STEM subjects can bring (Department for Education 2010; The Institute of Physics 2013b). However, even with this influx of activity, there is still a significant disparity between the numbers of girls and boys engaging with STEM. Although there has been an upwards trend in the number of female entrants in A-level Biology and Chemistry, the number of girls opting for A-Level Physics has remained static at 21% (Women in Science, Technology, Engineering and Maths, 2015).

With half of the world's population being under-represented, research and development and entrepreneurialism are stifled (Macdonald, 2014). These figures have led the UK government to question and investigate where the UK education system is going wrong and seek to repair the system (UK Commission for Employment and Skills, 2013).

In the early 2000's, the Institute Of Physics (IOP) found that the numbers of students taking A-Level physics were in decline and, in particular, the numbers of girls studying A-Level physics had stagnated at around 20% (Murphy and Whitelegg, 2006). School environment and culture had been identified as substantial factors in subject choice for girls (The Institute of Physics, 2013a). The IOP found further evidence that school culture can spread sexist or gendered language that reinforces gender stereotypes (The Institute of Physics, 2015). Careers advice and guidance is also poorly given, and students often don't know where a science qualification can take them (Archer *et al*., 2013).

The 'It's Different for Girls' report (The Institute of Physics, 2012, p. 5) summarised other key factors that can influence a girl's subject choices, such as student *Self-Concept:* how students place themselves in relation to the subject; how students experience physics at school; and, the teacher/student relationship and how supportive a student finds their physics teacher.

Within the classroom, students' experiences of physics lessons can be varied and teachers are often not aware of their unconscious bias which can perpetuate gender stereotypes. Qualified physics teachers are reported to be difficult to recruit (The National Audit Office, 2016) leaving a situation where, as illustrated by The Guardian newspaper, that teachers without physics degrees are being helped to teach physics, by people who don't have physics degrees either (Harris, 2016). The Guardian article implied that non-specialist teachers are more likely to need to use teaching aids, such as textbooks to support (a) their subject knowledge and (b) their students.

Publishers write textbooks to match and support the content of the National Curriculum. In 2011, the Trends in International Mathematics and Science Study (TIMSS) found that 78% of teachers in England used textbooks to supplement their teaching (Martin *et al*., 2011). Oates (2014) argues that the quality of the textbooks that were used by those teachers were of a poor standard and that this needs to change.

As far as can be ascertained, previous studies have not given any consideration to the influence that textbooks might have on a child's unconscious development of their gender identity or gender socialisation, even though Xiaoping (2005, p.2) noted that "textbooks are critical factors that contribute to the development of gender identity in children." If science education is to be made accessible to all individuals, then "one aspect of this inclusive perspective is that both females and males should be fairly portrayed in the science textbooks that provide an important resource for teachers of science in schools" (Elgar, 2004, p. 875).

STEM and Education: In 2004, The Institute of Physics (IOP) commissioned a meta-study by Murphy and Whitelegg (2006). Findings suggested that gender bias is a very complex issue and that teachers needed to do further action research in their classrooms (Hollins *et al*., 2006). Six years later, the IOP (2012) presented greater detail in what they had found the main influencing factors to be. In their report *Improving Gender Balance* (IOP, 2014), recommendations for improvements included appointing school based gender champions, analysing progression data and addressing unconscious biases.

Other vested parties include The Royal Academy of Engineers, Engineering UK, the Institute of Civil Engineers (ICE), the Institute of Engineering and Technology (IET), and the Institute of Mechanical Engineers (ImechE). These bodies are involved in providing funding and outreach to various STEM projects. Science, Technology, Engineering, and Mathematics network (STEMnet) are an organisation who are focussed on bridging the gap between industry and schools by training STEM professionals to be ambassadors in schools. Further more, initiatives such as Women In Science and Engineering (WISE, 2015), promote the personality traits required to be a STEM professional, so that girls can begin to identify with the qualities that it takes to be, for example, an engineer (MacDonald, 2014).

In England and Wales, the first opportunity to accurately judge the enthusiasm and motivation that students have for most STEM subjects is when they choose their A-level options at the age of 16. Before this, science and maths are compulsory subjects of study, and engineering is not taught. Girls are noted to outperform boys in science and maths at this age and will opt for some STEM subjects at A-level such as biology, chemistry, and psychology, but they do not choose to continue to study physics (Macdonald, 2014) as they perceive it to be hard (Barmby and Defty, 2006). Without physics, they are limiting their opportunities to enter the world of engineering and many other STEM careers. This evidence suggests that there are factors other than ability, which are influencing their choices.

The Aspires project (Archer *et al*., 2013) examined the aspirations that children have and, given the longitudinal nature of this study, were able to track the students and their attitudes over five years. Aspires reported that both girls and boys, at age 10, had high aspirations for careers in science, however, by age 14 (end of KS3) their career aspirations were still high, but not in science. Only 15% of the young people hoped to have a science career. Girls were particularly affected.

Adolescence is an important time in the life course and according to the gender intensification hypothesis, gender identities become more relevant at this time of life, with girls experiencing greater confidence drops during this time (Galambos, 2004) and greater emphasis on their appearance and relationships with boys as compared to the emphasis being on *achievement* for boys (Eder, 1995). There is compelling evidence that implicit theories about the malleability of traits (i.e. mindsets) can foster or inhabit the development of future selves. A study by Wonch Hill *et al.* (2017) has identified that fixed mindsets and boy-science biases are negatively associated with a science possible self. In other words if boys are seen to be naturally or effortlessly brilliant, and science requires brilliance, then fixed mindsets about intelligence and this boy-science bias, might contribute to girls becoming disinterested with less likelihood of becoming a scientist. In addition, Archer *et al*. (2012) found that families had a large influence on children's attitudes to science. Archer *et al*. (2012) take Bourdieu's concepts of capital and habitus (Nash, 1990) to suggest that within the bounds of family habitus there is valuable science capital to be exploited. A family with high science capital would welcome ways to support and grow their child's potential interest in science (Archer *et al*., 2012). It was noted that parents, along with teachers, could further extend their influence through helping to develop a growth mind-set in the child (Dweck, 2007; Hill, Corbett and St. Rose, 2010).

Many schools try to address the STEM issues by inviting role moles or STEM ambassadors to give talks or run one-off events in school. Van Radan (2011) ran a small-scale study to investigate the impact that role models have on inspiring students and found that there was little significant difference on the impact of the role models on girls' attitudes, but surprisingly a large impact on boys. The study was flawed, however, in choosing older, GCSE aged students and by having a small sample size. In comparison, from the outset, Betz and Sekaquaptewa (2012) succeed in presenting a well-argued, and evidenced study, reasoning that role models can have the opposite effect and demotivate girls from seeking STEM careers. A role model who was not only feminine but also clever and in a highly paid job created a stereotypical threat that was too difficult to emulate for most young girls.

Gender: Butler (2010) posed the question of whether gender is something you are or something you have? Social constructionism is the position that most psychologists and sociologists take, where, through studying how intersexed people (who have no clearly defined sex at birth) begin to construct a reality of a gender identity, through culture and society (Butler, 2010; Fine, 2010; Ryle, 2015). Opposed to this is biological essentialism where a person either fits into one category or another, like a binary code, through considering the persons' biological and genetic makeup and concluding that there are essential differences between males and females, sometimes known as "sexual dimorphism" (Ryle, 2015, p.427). This hormonal, biological position is defended by the study from Alexander and Hines (2002), where primates were presented with typical male and female toys. The results show that the primates chose to play with the appropriately gendered toy – male primates played with the male toy and vice-versa, suggesting that gender is something that is innately built-in to our brains. Neurologically, male and female brains are different. However, there are also too many differences between male and male brains or female and female brains to be able to draw any useful distinctions to explain the different choices that men and women make (Burnett-Heyes, 2015). Educationally, there are differences in the ways that males and females learn in the classroom. Boys tend to be more dominant, competitive and demanding for the teachers' time than girls. Girls enjoy learning through reading long passages of information; they like to take notes and record the results of experiments. They can have a lower self-confidence when it comes to practical work (Danielsson, 2012). Boys like to be more hands-on during practicals and like to access their learning through tables and charts (Department for Education and Skills, 2007; IREX, 2014). Interestingly, Retelsdorf, Schwartz, and Asbrock (2015) have found evidence that these differences are caused by the students' teachers' stereotypes.

Unconscious Bias: Teachers' stereotypes originate from their brains unconscious need to able to make sense of the world around them. The human mind is adept at developing patterns and filling in blanks of information using frames of reference from previous experiences that it has learnt from (Boeree, 2000). These gestalt principles mean that we categorise people and objects at great speed and therefore quickly develop biases constructed from cultural and societal encounters (Jones, 2015). Atherton (2013) refers to Piaget's cognitive constructivism, where the processes of assimilation involves beliefs that humans cannot just be given information that they immediately understand. Instead, human beings build their own knowledge and meaning through experiences. These processes give us views and opinions that we are not aware of and cannot easily control (Equality Challenge Unit, 2013).
Children are bombarded with gendered messages from the day they are born with which they have to assimilate and accommodate. When parents decide what colour and patterns to use to decorate their child's bedroom, gender is at the forefront of their mind. Buying toys for the child will be gender-dependent unless a conscious effort is made to make alternative choices. Even the patterns on clothes that children wear unconsciously add to their gender identity (Buckley, 1996). As they grow, they develop strong, hidden associations between objects and gender (Miller, 2010). The Harvard Implicit Association Test (IAT) (Diversity Council, 2017) is a longitudinal study, which measures the implicit attitudes and beliefs of any person taking the test. It analyses how deeply embedded unconscious biases are within the agent. In the ten years that this project has been running, the majority of agents taking the test have an automatic association of male with science and female with liberal arts. These results imply that most people have an unconscious bias against girls and science. This worldwide, invisible obstacle, can be seen in many areas of education and training (Michalec, 2011; Equality Challenge Unit, 2013), particularly in the secondary school curriculum (Wren, 1999; Lavey and Sand, 2015) and within textbooks (Blumberg, 2008).
Within science, stereotype threat leaves girls feeling that they do not belong, that maths and science are for boys. When girls find science challenging they believe that the reason is that they are girls and therefore don't perform as well as they could (Cornish, 2016).

The importance of textbooks in education: "Textbooks of high quality can assist teachers and learners and facilitate the development of science teachers" (Swanepol, 2010, p.iii). However, there have been very few studies on the quality and use of textbooks in secondary schools in England. Oates (2014) completed extensive research, comparing quality and use of textbooks across six countries and eight subjects, including Physics and Biology. The Oates (2014) paper discussed the positive effect of having good quality textbooks as a classroom resource for student learning, particularly when following the National Curriculum, but does not, however, consider whether implicit gender bias is a determining factor in what makes a good quality textbook.
Educational publishers influence on the curriculum is very variable. There is a tendency of publishers to replicate the market leaders, in order to maintain familiarity for the teachers (Oates 2014), however, this can lead to stagnation of the materials.

Elgar (2004) warns that the power of the textbook should not be overrated and that there are much greater influences in gender socialisation and in the choices that students make at A-level. Despite this, Martins and Garcia (2016) argue that school textbooks contribute to the development of school knowledge and hence school culture and therefore acting as an agent of the school culture, they cannot be ignored when looking at their implicit impression on students.

There are many studies available that discuss tools to help teachers assess the quality of their classroom materials in general (Wang, 1998; Koulaidis, Dimopoulos and Sklaveniti, 2001; Kahveci, 2010; Swanepol, 2010; Khine, 2013; Martins and Garcia, 2016) and although they give examples of tools used, these tools are not specific enough for the purposes of detecting the *genderness* of key textbooks.

Gender bias in science textbooks: There is limited published literature which considers gender bias in textbooks. There are a few resources which address the issue across disciplines such as English (Martins and Garcia, 2016), picture reading books (Ellefsen, 2015) and medicine (Alexanderson, 1999). Very few have a science focus (Whitely, 1996; Elgar, 2004; Kahveci, 2010; Sunar, 2011) and out of those very few, only two are British, though both authors were based in other parts of the world (Whitely, 1996; Sunar, 2011).

Whitely (1996) based his twenty-year-old study on seven physics textbooks published between 1985 and 1991, making them now several decades old. Clark-Blickenstaff (2005) noted that there were many relevant papers from the 1970's and 80's, from when feminine studies were first identifying and researching gender disparities. He stated that these papers showed a clear male bias, where women and girls were rarely represented in science textbooks. By 2005, he reasoned that there was a greater balance, through photographs, line drawings, the wording of questions/examples. However, both Sunar (2011) and Kahveci (2010) provide evidence that now opposes Clark-Blickenstaff (2005) claims, and they argue that there is still a male dominance within science textbooks. Sunar's (2011) research used a content analysis method to gather data from British A-Level books, through classifying and coding and found that although photographs were highly male orientated, the greatest gender disparities took the form of male names being used nearly 7x more often than female names through the textbooks.

Elgar (2004), focused her content analysis on illustration and text in science books used in Brunei. She agreed with Sunar (2011) that the textbooks showed a clear male bias, but she also found that *Marie Curie* was often the only female role model to appear in the books.

All other studies on textbook analysis shared the methodology of content analysis (Evans and Davies, 2000; Koulaidis, Dimopoulos and Sklaveniti, 2001; Lee and Collins, 2009; Gharbavi and Mousavi, 2012) and those that considered a gender bias focus found an overall male bias, other than Alexanderson (1999) who's major finding was that generally the books were totally gender neutral.

Measuring Genderness: In order to improve the gender gap within the classroom, a starting point for this would be for teachers to use a greater number of real-life contexts in teaching to show how the STEM topic relates to students lives and to provide examples of aspirational careers in lessons (The Institute of Physics, 2015). Ideally, this should contribute to the development of student identity and provide the teacher with a more engaged and motivated pupil (Grant, Bultitude, and Daly, 2010). The current standard teaching aids are core classroom textbooks, however, and to the best of our knowledge, there has been no measure of whether gender bias exists within these textbooks and whether this may be having a subtle influence on later A-Level choices and subsequent career. Wang (1998) developed a 'teacher friendly' gender measurement tool in order to analyse the content of 31 textbooks. Inter-rater reliability of that tool was α=0.60. It was suggested that revisions were required before the tool could be recommended for use by teachers. Other studies which have considered the substance of gender (Elgar, 2004; Blumberg, 2008; Brugeilles and Cromer, 2009; Kahveci, 2010; Sunar, 2011) used measurement tools in which language and image were common themes. However, no previous studies have developed a measurement tool which was designed to classify non-gendered images such as flowers or rockets. In the absence of a rigorous gender bias measurement tool, the Gender Bias 14, was developed in order to test the *genderness* of a subset of key science books.

The Gender Bias 14 Tool (AJPP Suppl 1): The Gender Bias 14 analysis tool is comprised of fourteen key questions which consider images and illustrations; the status of the person(s) within the images and illustrations; the use of language within the text, specifically pronouns and gendered words (Elgar, 2004; Rose, Spinks and Canhoto, 2015). It was deemed unnecessary to include an analysis of more complex language structures so as to allow the tool to be used in other applications in the future and to be as generalizable as possible. The number and type of role models (Brugeilles and Cromer, 2009) were also considered valuable data to be collected, as this could relate to the kinds of careers that the photographs in the textbooks are suggesting for males or females.

GB14 Code Book (AJPP Suppl 2): To ensure systematic and replicable data collection (Rose, Spinks, and Canhoto, 2015) the GB14 code book was developed alongside the GB14 tool. The code book describes how to use the GB14 analysis tool. It also outlines all the pictures and words that should be looked for within a corpus and gives instructions as to how to structure the data collection using different coloured pens and highlighters, as one image could be referred to under several of the GB14 questions.

Explicit Variables: Explicit variables in the codebook are the visual components of the content (Rose, Spinks, and Canhoto, 2015) and include the following:

- The number of images with a male or female person;
- The number of images of gender-free or equal gender images;
- The number of illustrations, diagrams, charts and tables;
- The number of male or female pronouns;
- The number of male or female role models.

Implicit Variables: Implicit variables are given more guidance within the code book, because the messages are hidden within the content and can be open to subjectivity (Rose, Spinks, and Canhoto, 2015). These variables were further refined after completing a pilot study and have been explicitly included in the codebook because they:

- Refer specifically to the male or female e.g. Father/Mother;
- Have a masculine/feminine connotation e.g. Handsome / Pregnancy;
- Are related to the pictures and objects that are used to introduce children initially to gender. That is, patterns on a child's clothes or images typically used in the décor of young a child's bedroom e.g. Trains/Fairies;
- Would be offered as typical toys to a young child e.g. Car/Doll;
- Represent jobs assumed to be male or female due to a traditional bias e.g. Police Officer/Nurse;
- Are technical words specific to the subject under analysis e.g. Pollen/Menstruation.

Hidden Variables: Hidden variables included the following values:

- The number of images of male or female objects - according to the rules above;
- The number of images where the status of the person was lowered or improved (for example, if the individual was pictured doing sport, their status was 'improved', but if pictured eating an unhealthy meal such as pizza, their status was 'lowered');
- The number of male or female terms - as outlined above.

Aim: Given that we live in an economy where Schools cannot afford regular purchases of new textbooks, there is a need for teachers and students to be able to assess their current textbooks for the hidden curriculum so that their own unconscious bias' can be identified and challenged. Therefore, this study describes the development of a new, simplified, reliable *genderness* measurement tool: the GB14. The new tool will allow Teaching and Learning Coaches (TLC's), teachers and students to analyse their textbooks for gender bias in image and text. The primary aim of this study was to investigate the extent of the gender bias in Key Stage 3 (KS3) Science textbooks in the UK, using the GB14.

Methods: Content analysis (Leeuwen and Jewitt, 2001; Neuendorf, 2010; Rose, Spinks, and Canhoto, 2015) was performed on the core Key Stage 3 science textbooks using the GB14.
Both manifest content, the visible gender bias of text and pictures and the much more imperceptible, latent content of the science textbooks (Rourke *et al*., 2001) were measured. The intention was to consider the latent content through an ethnographic content analysis lens as it focuses on 'situations, settings, images, meanings, and nuances presumed to be recognisable by the human actors/speakers involved' (Krippendorff, 2004, p. 34).
The authors recognised that they do not possess the same views as all women whose ideas are biased and influenced by their gender, culture, career, and experiences in science, engineering and education. Therefore, the view of the authors on what makes an image or a word feminine or masculine, would not necessarily be typical. A pilot analysis was undertaken to minimise the authors' subjectivity. The pilot ensured clear parameters could be pre-determined in the final code book.
Many studies agree that content analysis is a core set of protocols that allow us to examine human communications (Weber, 1990; Babbie, 2013; Krippendorff, 2004). The rigour required when embarking on such a study, is emphasised by Neuendorf (2002, p. 10), "content analysis is a summarizing, quantitative analysis of messages that relies on the scientific method, including attention to objectivity/intersubjectivity, a priori design, reliability, validity, generalizability, replicability, and hypothesis testing." This was to ensure that the GB14 would be as robust as possible.

Pilot Study: A pilot study was performed in order to test and refine the data collection tool (Cohen, Manion, and Morrison, 2011; Woolley, 2011). Five percent of the overall content (one full chapter of a textbook) was piloted.

A comparison of the results identified discrepancies, such as the classification of a figure which showed a field of flowers. This caused a lengthy discussion. It was agreed that at face value, the flowers could be thought to be gender free. However, it was possible that there was an inherent meaning within this picture. In our Anglo-European society, and 'androcentric unconscious' (Bourdieu, 2001, p. 5) it was unlikely that men would associate with flowers, other than to perhaps buy them for a woman. Therefore, both pictures of flowers and the word flower, could not be thought to be genderless and should be classified as feminine. Ryle (2015) delves deeper into where this belief stems from, and questions, how do we learn gender? Gender identity begins from the very moment a child is born, from how parents punish and reward their child, as they behave in a way that suits the child's gender. Ryle (2015) and Taylor (2003) discuss how 'gender schema theory' categorises characteristics and behaviours into masculine and feminine. This theory can be extended to explain why society accepts, and even expects that a girl would have a pink bedroom with butterflies and a boy a blue bedroom with trucks and diggers on his wall.
During the pilot phase, other inconsistencies were resolved following this theory, and it was agreed that the tool should include objects and terms that a young child sees in their bedroom as they are first introduced to the expected norms of being a girl or boy. For example, rainbows and butterflies would be classed as feminine and rockets and cars would be masculine. The codebook and data collection tool were adjusted accordingly with many examples, so as to improve reliability.

Inter-rater reliability: Following the pilot study, two independent raters were given the tool to conduct the quantitative analysis on 5.5% of the textbook material (one chapter each) repesenting 11% of the overall corpus. Two-way mixed model Intraclass Correlation Coefficient and Cronbach's Kappa were used to test for measurement of absolute agreement between the two independent raters scores and the two authors scores.

The Sample: Key stage 3 science textbooks (*n = 3*) containing eighteen chapters in total, were included (convenience sample). Together, these eighteen chapters cover the content of England's new National Curriculum for Science. The three books, as displayed in Table 1, had six authors; four females, two males (Askey *et al*., 2014; Baxter *et al*., 2014a; Baxter *et al*., 2014b). Three authors worked across all three books, two females, and one male. It is not clear which author was responsible for which chapters within the textbooks. Interestingly all books have the same male editor.

This sample represents the total provision of core textbooks for key stage 3 science, as opposed to a random sample of the material, as would be usual in content analysis (Brugeilles and Cromer, 2009). Data were collected manually and analysed for *genderness*, from all of the chapters, using the GB14.

Series Editor:	Ed Walsh	
Authors	**Year of Publication**	**Name of the book**
Sarah Askey, Tracy Baxter, Sunetra Berry, Pat Dower	2014	**Book 1** Collins Key Stage 3 Science Student
Tracy Baxter, Sunetra Berry, Pat Dower, Anne Pilling	2014[a]	**Book 2** Collins Key Stage 3 Science Student
Tracy Baxter, Sunetra Berry, Pat Dower, Ken Gadd, Anne Pilling	2014[b]	**Book 3** Collins Key Stage 3 Science Student

Table 1: Textbooks used as the corpus of material for data collection.

Results and Analysis: Descriptive data are presented as frequency and percentage. Inter-rater reliability of the GB14 was determined by Intraclass Correlation Coefficient using Statistical Package for the Social Sciences (SPSS). For qualitative analysis, the inferences of underlying messages in image and text based on the presence or absence of some evidence in the images and text are put forward. Descriptive quantitative analysis was also used for (a) Male/female role models, (b) Status of males/females in images, and (c) Other observations made.

Inter-rater reliability of the GB14: Using the two-way mixed model Intraclass Correlation Coefficient, inter-rater reliability scores between rater one and author one was α = 0.98 (CI. 0.94 – 0.99) and between rater two and author two was α = 0.94 (CI. 0.83 – 0.98).

Data Analysis and the 'Genderness' Score: Eighteen chapters were analysed using the Gender Bias 14 Analysis Tool (GB14). Data were aggregated and a total *Genderness* score allocated to each chapter. This number was then used to illustrate the gender bias of a chapter by using the '*Genderness'* Scale as described in the GB14 score book. A *positive Genderness score* represents male bias and a *negative Genderness score* represents a female bias.
Figure 1. shows The 'Genderness' Score for each chapter. The data is also colour coded to represent each textbook analysed: (a) Green – Book 1; (b) Blue – Book 2 and (c) Red – Book 3.

Book 1: Chapter 5 and Book 3: Chapter 5, show the

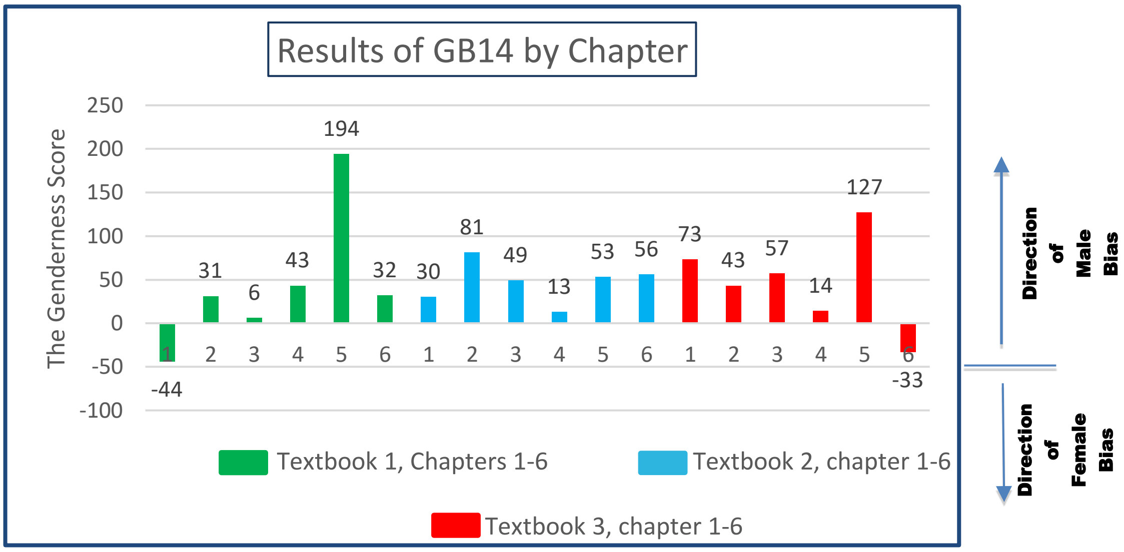

Figure 1: The results of the Gender Bias 14 analysis tool by chapter

Book 1: Chapter 1 (*Biology*) and Book 3: Chapter 6 (*Physics*) are the only chapters showing a female bias.

The Genderness Scale also generates a descriptor of the level of bias according to the score, so that chapters can then be rated and compared, as seen in Table 2. The table has also been colour coded, as above, to show the results of each book clearly, and openly indicates that 72% of the eighteen chapters were at a medium level of male bias or above. So, almost three-quarters of the *chapters* had a difference of 15 or more occurrences where male images or language were used more than female.

Considering the overall effect, the conclusion is that this collection of textbooks is shown to have an overall significant male bias of 92%.

Figure 2 presents the raw frequency count data for the overall study and categorises it into the four key areas of the GB14 tool.

From this figure, it can be seen that Male images account for almost double the number of female images used throughout the KS3 course.

KS3 Science Textbooks		*'Genderness'* Score		
		Male	Female	Descriptor
Book 1	Chapter 1	0	44	Medium Level Female Bias
	Chapter 2	31	0	Medium Level Male Bias
	Chapter 3	6	0	Low-Level Male Bias
	Chapter 4	43	0	Medium Level Male Bias
	Chapter 5	194	0	Very High-Level Male Bias
	Chapter 6	32	0	Medium Level Male Bias
Book 2	Chapter 1	30	0	Medium Level Male Bias
	Chapter 2	81	0	High Level Male Bias
	Chapter 3	49	0	High Level Male Bias
	Chapter 4	13	0	Low-Level Male Bias
	Chapter 5	53	0	High Level Male Bias
	Chapter 6	56	0	High Level Male Bias
Book 3	Chapter 1	73	0	High Level Male Bias
	Chapter 2	43	0	Medium Level Male Bias
	Chapter 3	57	0	High-Level Male Bias
	Chapter 4	14	0	Low-Level Male Bias
	Chapter 5	127	0	High-Level Male Bias
	Chapter 6	0	33	Medium Level Female Bias

Table 2: The 'Genderness' descriptors for each chapter.

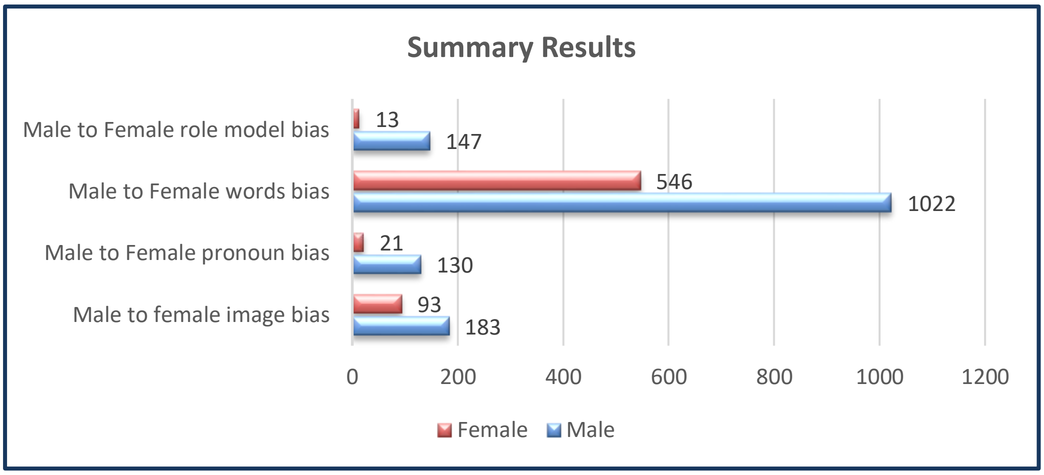

Figure 2: Overall results for the four key areas of study of the GB14 tool.

Male pronouns were used over five times more often than female pronouns. Substantially more male gendered words used than female-gendered words.

The data about Role models was the greatest surprise, with eleven times more male role models than female role models. It should also be noted that the majority of these male role models were historical male scientists.

Results of Image with respect to subject: Although students at Key Stage 3 (KS3) will study science as a whole subject, Macdonald (2014) discusses the difference in uptake at A-Level across the three main science subjects and identifies that physics is much poorer than chemistry or biology. With this in mind Figure 3 compares the frequency count of images for the individual subjects physics, chemistry, and biology.

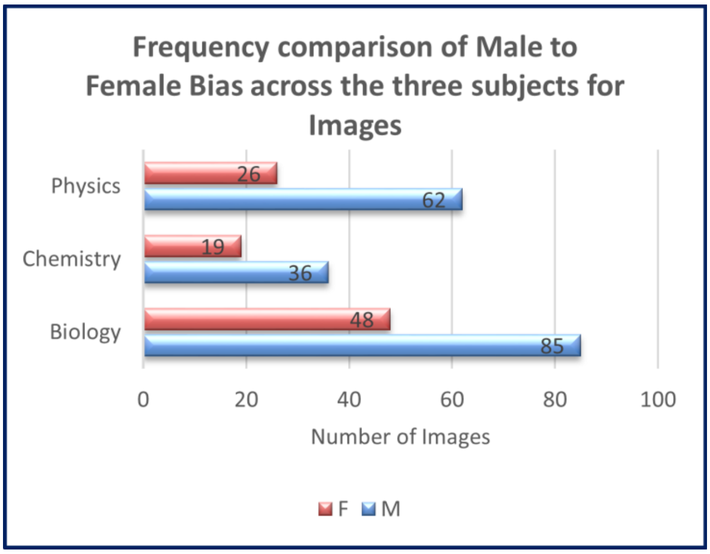

Figure 3: Frequency comparison for Male and Female bias for Image across physics, chemistry, and biology

Figure 3 shows that physics and biology have the greatest difference between male and female images and interestingly, although biology uses the most gendered pictures, figure 4 indicates that the percentage ratio for male and female images is very similar to chemistry, both being 64% and 63% respectively.

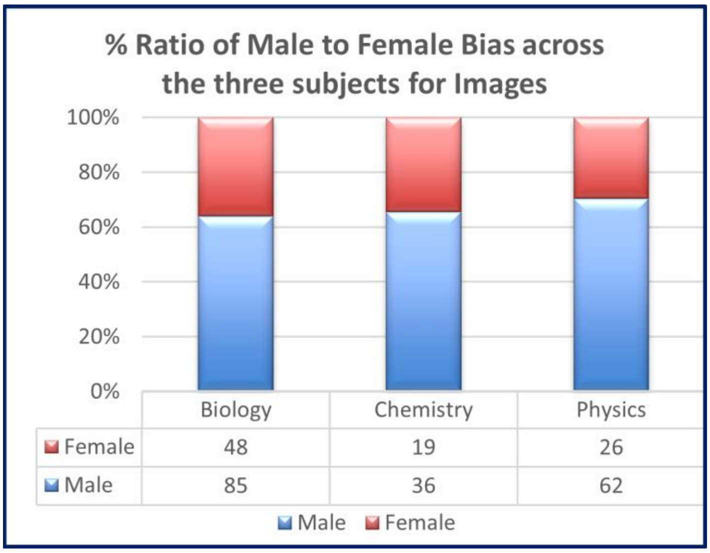

Figure 4: Percentage ratio of male to female images in subjects

Results of Language with respect to subject: Figure 5 shows again that there is a male bias across all three subjects this time with respect to the words used to refer to gendered nouns.

The gender difference in biology, though, is significantly reduced, as compared to the difference in physics. In the physics chapters, there are 346 more occurrences of male words being used.

When data is processed to consider the percentage ratio, as shown in Figure 6, the gender bias becomes increasingly apparent. Only 14% of the gendered words used in the physics chapters were feminine.

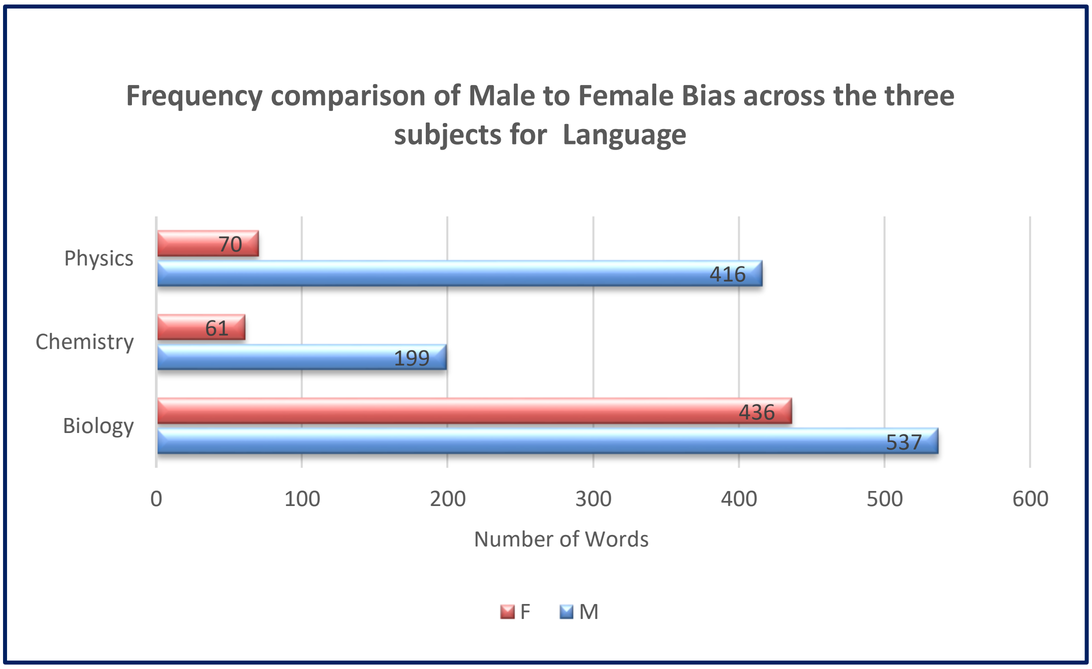

Figure 5: Frequency Comparison of Male to Female Bias for Language across physics, chemistry and biology

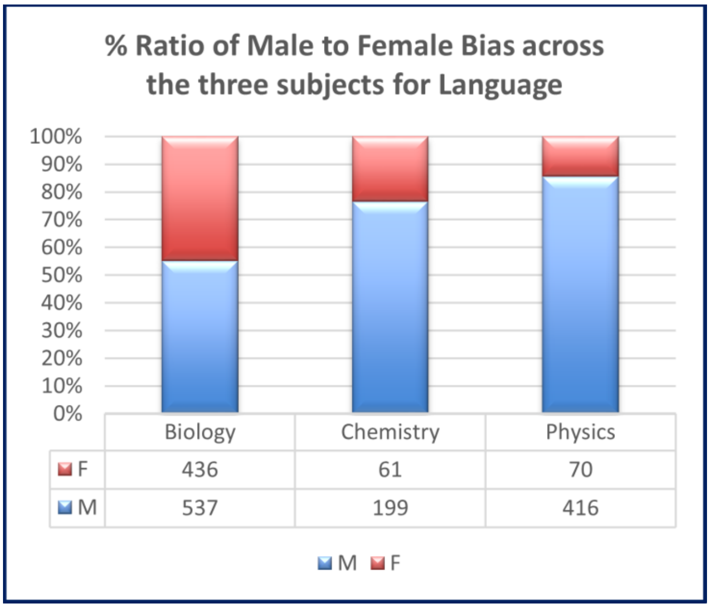

Figure 6: Comparison of percentage ratio of gendered words across biology, chemistry, and physics.

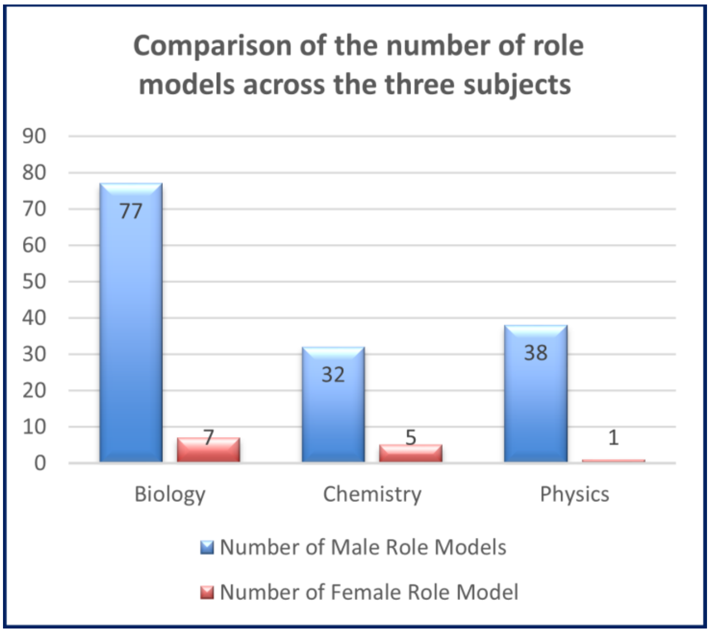

Figure 7: Number of role models in KS3 Textbooks

Results of Role Models with respect to subject: Figure 7 shows the results for the number of male or female role models across the three science subjects. Again there is a distinct bias towards males. There are only 13 occurrences where female role models are referred to throughout the entire collection of textbooks. The data also show a trend where there are more biology role models overall. There is a higher percentage of female role models (13.5% *n*=5) for chemistry than biology (8.3% *n*=7) and physics (2.6% *n*=1).

Male/females role models: Intriguingly, the only female role models to be referred to were both historical scientists; Rosalind Franklin, and Marie Curie. The text that followed both women presented a story whereby either they supported other (male) scientists, or they were supported by male scientists. It could be inferred from this that they could not have made their discoveries on their own.

Status of males/females in images: Using Pearson's X^2 to test for differences between the number of occurrences in image, where the status of the male or female was affected was significant (p=0.04), where the males' status is improved more often than the female and the females' status is lowered more often than the male, thereby possibly implying that females are weaker and more needy in comparison to the stronger, healthier male (Table 3).

Male Status	13	Lowered
	24	Improved
Female Status	17	Lowered
	12	Improved

Table 3: Showing the frequency count for the number of images where the status of the person in the pictures was lowered or improved.

Further observation: Most images were gender-free, or gender-equal and the textbook authors had made an attempt to keep the language as gender-free as much as possible.

Discussion:

Problems with the method: This method uses a very simple to follow tool, however when applying it to complete sets of textbooks, it is extremely time-consuming. Therefore using software packages such as Atlas/ti®, NUD*IST® or HyperQual® may allow coding categories to be assigned for qualitative data collection and could produce results with an opportunity for greater detailed analysis (Rourke *et al*., 2011). A limitation to this would be obtaining copyright clearances to store the textbooks in an electronic form. Another alternative method could be to consider how textbooks are used by teachers. Often teachers are selective about the chapters that they use with students. Therefore, a sampling method, focusing on those chapters that are not accompanied with many practical experiments, may give a more realistic view of how often students are exposed to the hidden content.

Deciding on a justification for why one word or image could be classified as male or female was also very challenging. There was very little published research on gendered objects (Buckley, 1996) and none with a definitive guide. Discussions surrounding what constituted 'status lowering' were similarly subjective. For example, it was decided that if a person in an image were seen eating pizza or smoking or sat down watching TV, then they were considered less healthy and awarded a 'status-lowering' mark, whereas being pictured outside jogging or eating salad or at the gym, were perceived to be the more healthy 'status-improving' image.

As no other researchers have used this subjective discursive classification method, researcher subjectivity remains an issue with the GB14. In future iterations or applications, methods to minimise researcher subjectivity further would be recommended.

Discussion of the results: These books are not free of gender stereotypes, however, many gender neutral terms are used. They are significantly biased towards the learning of males and encourage the idealism that science is the domain of the male sex.

Chapter 1 book 1 – Cells and reproduction is especially interesting, as it was the only chapter to compare differences between male and female bodies. This chapter was unusual, as it had many explicit occurrences of gender due to the nature of the topic of study, reproduction. There was a high number of references to both males and females and it is only one of two chapters that was seen to have an overall female bias. The other female bias chapter came from Book 3. This was unexpected because it was a physics chapter and yet all of the other physics chapters exhibited Very High Levels of Male Bias, according to the 'Genderness' scale. In this case, the focus was on the topic of light, which brought up the discussion of rainbows and how they were made. Rainbow had already been defined as a female word and so caused the gender balance to tip. The gender bias of the chemistry chapters was also of interest, as three of the chapters, one from each textbook, resulted in a Low-Level Male Bias. These were the closest to being gender neutral.

Other themes, for discussion, came from observations of image and text together. For example, the authors here questioned the semiotics of figure 8 (Note: Permissions were not gained to reproduce the original image from text book 1 and so this is a remarkably similar image taken from Flickr.com (2017)). What story is the picture trying to tell? There is a man sitting next to a newborn baby in an incubator. On the first look at this picture, it would be easy to assume that the male is the baby's father, which would pass on the very positive message, that fathers are expected to be around at the birth of their babies. It may be concluded at this point that the picture is improving the status of the man, as he is seen in a supportive, caring position, which is normally reserved for a woman. However, when the text below is examined, there is a distinct hidden message. The statement under the picture suggests that the mother is unavailable due to her dependence on cigarettes causing damage to the vulnerable baby. Often, text under pictures did not relate to the gender of the person in the picture or the text tried to remove gender, such as an explicit picture of a boy on a skateboard who was given the general descriptor of 'skateboarder' without any reference to his gender (Askey *et al*., 2014, p. 171). This corpus clearly tried to hide the references to gender, while still allowing an unbalanced view to occur. Too often, boys' names were used in questions, where the authors could have ensured that if they used boys' names, then there were an equal number of girls' names too.

Figure 8: An example from Book 1 Chapter 1: Male and Baby

NB: This is not the original image from Text Book 1 but this is a very similar image taken from https://www.flickr.com/photos/jimbl/4451042141/in/photostream/

FIGURE 1.1.18b: Possible consequence of smoking during pregnancy

[Text is as written in the original textbook 1: Askey *et al*., 2014].

Role models: The way in which role models were presented in these textbooks was very limited as was also found by Elgar (2004) and Sunar (2011). Bourdieu (2001) sees the 'dehistoricisation' of women as one of the key objectives that must be stopped to combat the androcentric worldview that we surround ourselves with.

It was disappointing that there was a preponderance of historical male figures. These books do not reflect life as it is today and therefore prevent females students from seeing where they might fit into science's bigger picture. This lack of positive role model leads to students being unable to identify with scientists and certainly does not provide any aspirational career choices for girls or boys. These textbooks do nothing to improve the student identity within science and physics, but instead encourage girls to perceive science as a boy's subject.

It is important that all students have an opportunity to reflect critically on the impact of gender on their own lives and relationships, both at the present and in the future and to unravel the ways in which institutions and practices act to maintain unequal and gendered ways of being and relating.

Adults' minds are already framed around their own personal experiences. However, the "behaviour of adults can also lead to an alteration of gender norms" (Ryle, 2015).

"Once we know that biases are not always explicit, we are responsible for them. We all need to recognise and acknowledge our biases and find ways to mitigate their impact on our behaviour and decisions" (Equity Challenge Unit, 2013 p. 3)

This change needs to begin within the education system and in schools. According to Bourdieu (2009), the way many different cultural products are appropriated is related to the position, situation and disposition expressed by agents in the social structure. "If schools were to become a vital instrument towards liberation and transformation, then most likely they should function as the agent of change and development of minds." (Tantengco, 2014).

Conclusions and Recommendations: The Key Stage 3 textbooks under scrutiny here appear, at face value, to be gender neutral. Most of the images and language used, avoid references to people, but this acts as a smoke-screen, hiding the strong male bias (Boeree, 2000) and feeding students' and teachers' unconscious biases. This perpetuates the acceptance of the androcentric world as the norm (Bem, 1993; Bourdieu, 2001).

The GB14 analysis tool has determined that the Collins Textbooks for Key Stage 3 Science are very highly gendered and have a strong bias towards males which, whilst not directly measured here, has the potential to severely disadvantage females students within the classroom. This further adds to the 'Hidden Curriculum' which reportedly influences student life choices (Wren, 1999; Blumberg, 2008; Michalec, 2011).

Essentially the Key Stage 3 science textbooks are continuing to re-enforce Bourdieu's (2009) concepts of Masculine Domination, especially since the gender bias is not always explicit from the outset. The textbook authors have missed the opportunity to provide a gender balance by showing equal numbers of male and female role models or to provide equal numbers of positive examples of both genders. Within the world of science, technology, engineering, and maths, students need to begin to identify with the characters within the books and see the STEM subjects as a possible career pathway. The authors have missed an opportunity to break down stereotypical ideals. The GB14 tool itself, has been shown to have high rater-reliability and therefore has the potential to be endorsed by important institutions, for example, the Institute of Physics in their work on Improving Gender Bias with teachers and students.

The GB14 tool was designed with the aim that it could be used to consider the gender balance within current and future science textbooks as well as other styles of publication or texts. The criteria for the GB14 codebook can be reviewed and adapted as necessary to suit the focus of any future studies. The criteria should also be reviewed every 5 years in order to add or delete gendered words, keeping it up to date and ensuring continued robustness and longevity of the tool.

Additional Applications of the GB14 Tool:

It is recommended that teachers should use the tool with their students, both male, and female, with their current textbooks. Examining gender bias in their textbooks, as a lesson focus may increase their students' awareness of unconscious bias, and begin to remove the implicit meanings from the textbooks. "Being aware of the ways that gender permeates our lives can give us invaluable insight into the world" (Ryle, 2015, p. 3).

It is also recommended that teachers currently using the Collins Science textbooks could supplement their use with other materials which provide a better balance of female to male role models. For example, to use alternative examples for teaching motion other than 'cars', or, to use pictures and examples of females in career situations that help all students to relate to science and an equal gendered possible career option.

It is further recommended that Teaching and Learning Coaches who run specific workshops could use the GB14 tool in a session on *genderness.* The session would give an opportunity to hand the teacher a physical device that they to take back to their classes and use to help address the gender issues. As Archer *et al*., (2013) state, teachers need support to challenge their unwitting biases.

Lastly, the tool could also be used to increase the awareness of the gender divide in other subjects, contributing to a whole school approach to having a better gender balance throughout the school's culture.

Recommendations for publishers: It is further recommended that publishers could consider the application of the GB14 analysis tool to any new textbook draft in order to apply a *Genderness* Score against the new textbook. The use of this tool would identify any gender bias before it is too late to halt publication.

Publishers and authors may also consider presenting a greater balance so that equal numbers of male and female images, words and role models are used to represent the world more like the one the students are growing into.

It is unlikely that gender bias will ever be eliminated, but the more tools that can be created to help teachers and students become more aware of the hidden messages of inequality, then people are more likely to challenge their own biases and give them space to grow. "Once we know that biases are not always explicit, we are responsible for them. We all need to recognise and acknowledge our biases and find ways to mitigate their impact on our behaviour and decisions" (Equity Challenge Unit, 2013, p. 3).

The authors of this study believe that gender representation is an important issue in the design of teaching materials, and welcome the efforts of other scholars and educators to examine a variety of materials and share their findings to continue this discussion.

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