Gendered Science: Representational Dynamics in British Columbia Science Textbooks over the Last Half Century

Paz Villar
University of British Columbia

Neil Guppy
University of British Columbia

Abstract

Gender continues to segregate schools despite substantial progress in promoting gender-equity. The practice of science has long been associated with masculinity (e.g., rational, objective, and unemotional) but there have been recent attempts to assert a more nuanced gender balance in science education. These would include highlighting female scientists in curricula, teaching science in ways more appealing to both girls and boys, and providing female as well as male role models in textbooks. The concepts gender balance, gender roles, and gender framing are used to focus our analyses. We investigate the representation of gender by analyzing images and the context surrounding these images in BC science textbooks used in Grades 7 to 11.

Keywords: gender, role models, science education, socialization, content analysis

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Résumé

Le genre continue d'être une source de ségrégation dans les écoles en dépit des immenses progrès réalisés dans la promotion de l'égalité entre les sexes. La pratique de la science est depuis toujours associée à la masculinité (à ce qui est, par exemple, rationnel, objectif et neutre), mais on a tenté récemment d'assurer un équilibre plus nuancé dans l'enseignement des sciences, notamment en présentant des femmes scientifiques dans les programmes, en utilisant des méthodes pédagogiques plus intéressantes pour les filles comme pour les garçons et en fournissant des modèles de rôle féminins et masculins dans les manuels. Les concepts d'équilibre entre les sexes, de rôle des sexes et de cadre sexospécifique sont utilisés dans nos analyses. Nous étudions la représentation du genre en analysant les images et leur contexte dans les manuels de science utilisés en Colombie-Britannique à partir de la 7e année jusqu'à la 11e année.

Mots-clés : genre, modèles de rôle, enseignement des sciences, socialisation, analyse de contenu

Introduction

The majority of the world's university students are female. Women constitute 73% of education majors and 65% of all arts and humanities students, but only 34% and 36% of engineering and science students, respectively (UNESCO 2013–14, Table 9B). Canadian figures mirror the global pattern: Women in Canada earn over 40,000 *more* undergraduate degrees every year than do men, yet they remain seriously underrepresented in the science and engineering fields. The recent and significant growth in the number of women graduates in previously male-dominated areas such as business, law, and medicine has not occurred in the STEM disciplines (science, technology, engineering, and mathematics). While the historic pattern of gender segregation has eroded somewhat across all fields of study (Davies & Guppy, 2014, p. 140), the gender balance in STEM fields has been notably resistant despite substantial attention (Natural Sciences and Engineering Research Council of Canada, NSERC, 2010).

This persistent discrepancy in the male:female balance in STEM fields matters for at least two reasons. First, it matters for individual well-being because earnings, job satisfaction, and prestige are all relatively high in STEM fields (Ostrovsky & Frenette, 2014). The presence of fewer women in these high-earning occupations partly explains the wage gap between men and women, and also helps explain why women are less prominent in positions of influence and authority in Canada. Second, it matters for national well-being because it means that the skills and abilities of women are less available in a crucial sector of the knowledge economy. The full intellectual and creative power potentially available for everyone's collective benefit is circumscribed because of this ongoing gender imbalance in fields of study.

This issue of gender imbalance is especially consequential. Women who do well in math and science, thus clearly demonstrating the intellectual capacity to contribute in STEM fields, often fail to pursue those fields beyond high school. For example, the most recent international data from PISA (Programme for International Student Assessment) showed that men with lower mathematics test scores were significantly more likely to enter and graduate from STEM fields than were women who, at age 15, achieved *higher* mathematics scores than their male peers (Hango, 2013a, 2013b). Similarly, using Canadian test results, NSERC (2010, p. 3) concluded that "boys tend to outperform girls by only a slight margin for both mathematics and science." Why do women shun STEM fields despite this modest gap? As NSERC noted, "a lack of female role models in science and engineering is commonly cited as a major reason" (NSERC, 2010, p. 13).

If the gender segregation between STEM and non-STEM fields is not due to cognitive ability, as this evidence demonstrates, then what does account for the imbalance between the fields of study chosen by women and the fields chosen by men? Is there a bias, as NSERC suggested, that is moulded over the course of early life and tied to role models and formative student decisions about non-traditional gender careers? One powerful explanation of girls' aspirations is that science is associated with masculinity and, because of this, young women are more likely to gravitate to other fields where they can construct identities that better mesh with their sense of who they are and who they would like to become (Charles, 2011).

Masculinity and Science

The Council of Canadian Academies has recently called for "role models who defy gender expectations" (2012, p. 141) while simultaneously cautioning that "gender schemas and stereotypes…contribute to a lack of encouragement and support for girls" (p. 140). These concerns led us to examine whether or not the last half-century has witnessed any changes in the portrayal of women and men in the science curriculum. Because the link between masculinity and science is an important context for understanding the gendered nature of science, we begin with a brief review of those issues. We follow this with a short accounting of the degree of change in gender representation in science, and in other areas of social life, showing that changes in gender balance have been uneven across both time and space. Here, especially, we also stress the impact of role models on young people who are in the process of constructing their identities. Based on these two reviews of current research, we formulate a series of hypotheses that we test using evidence from British Columbia school textbooks, books that are very similar to, and in the past often identical to, those used in other English-speaking provinces. We show that, although the representation of women in images has become more balanced, the association between masculinity and science is still pervasive in the ways science is presented in school texts, both in terms of gender roles and the ways gender is used in framing scientific concepts.

Historically, science has been associated with men and masculine characteristics. The practice of science is defined by rationality, objectivity, and emotional detachment, all routinely understood as masculine traits (Oakley, 2000). In this sense, not only have men produced the majority of extant scientific output, but their dominance in the field has led to a culture of science infused with a masculine ethos including winner-take-all competition, technical bravado, individualism, and, in particular, the domination of nature (Kelly, 1985; Archer et al., 2010). Furthermore, it is not just the practice of science that is associated with masculinity, but also science education (Brotman & Moore, 2008).

One significant consequence of this association between science and masculinity is that, because femininity is most often constructed in opposition to masculinity, there is a tendency to imagine femininity as being in opposition with science. As a result, femininity is pitted against other highly valorized attributes, such as intelligence, objectivity, and logical reasoning. The constructed association between science and masculinity pushes girls away from scientific fields and leads to the persistent underrepresentation of women in science. This process works in subtle ways. In their recent review of research, Brotman and Moore (2008, p. 978; Archer et al., 2010) found that girls' overall attitudes toward science are less positive and—more significantly—decline with age, especially after elementary school, because of their tendency to perceive science as difficult, uninteresting, or leading to an unattractive lifestyle. Even when girls enjoy science, they perceive their competence as lower than that of boys, a pattern of self-assessment that persists even when they perform as well as or better than boys. Furthermore, when asked to draw a picture of a scientist, children are much more likely to portray males. Not without coincidence, popular culture reinforces these images, as witnessed by CBS's comedy success, *The Big Bang Theory*, which originally featured four male scientists and a female waitress. (More recently, two female biologists have joined the show.)

Finally, the ways in which science has traditionally been taught favours the learning styles most frequently preferred by boys and less preferred by girls. Scripted laboratory experiments and lecture-style presentations predominate, and the collaborative, discussion-based, problem-solving styles more appreciated by young girls are shunned in much science teaching (Baker, 2013). The links between industrial production, technological advancement, and military applications found in science and science education also tap into a set of values more aligned with masculine than feminine identities.

Gender Representation, Role Models, and Social Change

Among the repeated and more prominent recommendations advanced to enhance the entry of women into STEM fields is the suggestion of role modelling. The idea that the career aspirations of young women are shaped by their reference groups was a concern of the 1970 *Report of the Royal Commission on the Status of Women* and this concern has most recently been repeated by the latest panel investigating the continued paucity of women in science (Council of Canadian Academies, 2012; NSERC, 2010).

Although the relative scarcity of female role models in science presents a challenge, recent research has demonstrated that, even with respect to atypical roles, reference groups and role models can be consequential. Croft, Schmader, Block, and Baron (2014) demonstrated that, when fathers defy gender expectations and take on more of the domestic labour in the household, their daughters are more likely to aspire to non-traditional female jobs. Even more germane to the current study, Stout, Dasgupta, Hunsinger, and McManus (2011) found that role models can help in enabling young women to consider careers in STEM fields (Baker, 2013; Cundiff, Vescio, Loken, & Lo, 2013). Young women have begun choosing career trajectories in many non-traditional fields, including business management, law, and medicine, where they are often now equally represented with men (Davies & Guppy, 2014, p. 140). This latter pattern demonstrates that women can shatter gender-conformity sex-typing traditions, but it simultaneously highlights the contrasting situation in STEM fields, where gender imbalance persists.

Gender balance has been much studied recently—in advertising (Baumann & de Laat, 2012), in colouring books (Fitzpatrick & McPherson, 2010) and cartoons (Thompson & Zerbinos, 1997), among superheroes (Baker & Raney, 2007), on scientific websites (Mendick & Moreau, 2013), and in children's literature (McCabe, Fairchild, Grauerholz, Pescosolido, & Tope, 2011), to name a select few. Many of these studies have shown signs of change toward more egalitarian representation, but nowhere is there a finding of true gender balance. As McCabe et al. (2011) argue, based on an examination of titles and central characters in award-winning children's literature across the span of the last century, "persistent patterns of inequality remain" even though there has been some progressive change in gender representation. School textbooks, including science books, have been less studied recently and those few studies that have been done show some progressive change but no gender balance (Brotman & Moore, 2008). Across time and place and topic, the research literature has shown some basic positive change but nothing approaching equal gender representation.

Hypotheses

Given these findings, we anticipated the following three hypotheses in our examination of British Columbia science textbooks:

> **Hypothesis One**: We would find greater male than female representation, although with a recent trend toward gender balance.
>
> **Hypothesis Two**: We would find more males than females portrayed in positions of authority, engaged in doing science, and as scientists, but again with a trend toward more balance in gendered roles.
>
> **Hypothesis Three**: We would see continuing evidence of gender bias built into the ways science is actively constructed or framed in school texts.

The first hypothesis focuses on gender balance (e.g., proportions of women and men in images), the second on gender roles (e.g., types of activities in which women and men are depicted), and the third on gender framing (e.g., how gender is used in illustrating scientific concepts).

Methods

We conducted a content analysis of human images, both photographs and drawings, found in science textbooks for Grades 7 through 11. Brugeilles and Cromer (2009) provide a methodological review of such analyses and we follow their approach as closely as possible. For a recent Canadian example, see Mujawamariya and Hamdan (2013). Science is compulsory through these grades and so we know that all girls and boys are expected to make use of the texts we analyzed. To investigate trends over time we examined textbooks that we loosely categorized into three time periods according to publication date: the 1950s to 1960s; the 1970s to 1980s; and the most recent two decades, the 1990s to 2000s (see Appendix 1 for a list of textbooks used). We recognize that these periods are not mutually exclusive in that some books have been used in more than one time period, but alternative divisions into different time periods would not circumvent this minor issue. Texts from earlier eras were not analyzed because they were not systematically available. Textbooks were selected from the lists of recommended and authorized books published by the Ministry of Education of British Columbia for each academic year. As is common with textbooks, these books, or very similar books, were used elsewhere in Canada as well, although not consistently across every province. Books without human images were not used.

We chose school textbooks for our study because they are powerful sources of knowledge in which information is delivered as hard fact. As Elgar (2007, pp. 879–880) explained, children as well as teachers perceive textbooks as culturally significant, especially because of the compelling way they influence gender socialization. For a variety of reasons, we decided to focus our analysis on textbooks from Grades 7 to 11. First, it is generally through this age range that other scholars have noticed the most change in the identities boys and girls develop with respect to science (e.g., Archer et al., 2010; Baker, 2013). Second, since some science study is mandatory through this period, this enabled us to avoid the differential gender course enrolment that occurs in later grades and in the post-secondary system due to a greater selection of subject electives being offered.

We began by identifying images and then counting female and male figures. This is the major way in which gender representation has been studied historically. Also, images have potentially stronger effects than words. Low and Sherrard (1999) argued that the reason images are so powerful, and in particular photographic images, is that "readers assume they are objective slices of reality, thus giving the photographs authority and allure… Photographs can thus carry connotations, be they intentional or not, never stated in the text" (p. 311). Furthermore, and especially in recent years, young people are from an early age immersed in a visual culture, whether through television or videos. The ability to read images is perhaps a more practised art than reading text. How teachers position the use of textbooks in classroom activities shapes some of the reception students have to images. This no doubt complicates how readers react to representations, sometimes by reinforcing stereotypes and at other times challenging conventional interpretations (Pinto, 2011; Pinto, McDonough, & Boyd, 2011).

The coding scheme for gender representation was relatively straightforward, save for the following notes. In some images the gender of human subjects was not apparent.

For example, even though a photo of a fully suited astronaut may create a quick association with masculinity, if there was no text around the image identifying the gender, then we did not include the image in our counts. In addition to coding images for gender, we also included codes for context (e.g., being in a science lab, being outdoors), power (e.g., authority positions), activity (e.g., active or passive, operating machinery or appliances), and occupation (e.g., doing science). For example, images coded for "authority" were illustrations in which more than one individual appeared and in which at least one person was in an obvious position of power relative to others.

At first we concentrated on counts of women and men in images (hypothesis one) and the frequency of images depicting either males or females in particular roles (hypothesis two). With our second and third hypotheses we chose to explore beyond the images—we tried to move beyond simply counting gender in images to understanding more about how images might be interpreted. It is not only the representation itself that matters but also the activity or context of the representation. Boys and girls may both appear in a picture of a science lab, for instance, but if the boys are doing the experiment and the girls are observing, this sends a very particular message about scientific practice. In other words, exactly what it is that is being role-modelled needs to be taken into account.

We also know that textbook publishers are required by Ministries of Education to be cognizant of bias in the books they publish. Gender representation in images is often explicitly itemized as an area of concern. Still, even if representation has become more balanced, there could still be gender biases embedded in the ways the educational material is presented. We speculated that we would see positive, progressive change in the gender balance of images but that the subtle, nuanced framing of materials might nonetheless infuse texts with gendered schemas and stereotypes (hypotheses two and three).

Findings

The historical patterns of change in gender representation were most clearly seen by examining two primary trends. The first trend considered all the human figures found in the science textbooks, and showed the percentage of these images that included women. Here, the unit of analysis was the image. This is shown in the rightmost columns of Table 1. Starting in the 1950s, women were represented in just under one-third (28.9%) of all images containing human figures. The representation dipped modestly in the 1970s and 1980s when women were in only about one-fifth of all images, but the pattern rebounded sharply; now almost half of all images contain women (44.3%).

Table 1. Images of Women and Men, and the Numbers of Women and Men, in School Textbooks across Three Cohorts (1950s to 2000s).

	Total number of		% Women		Images including		% Women
	Men	Women			Men	Women	
1950–1960s	710	233	24.7		293	119	28.9
1970–1980s	402	51	11.3		220	51	18.8
1990–2000s	790	604	43.3		546	435	44.3
Total	1902	888	31.8		1059	605	36.4

The leftmost columns of Table 1 provide a second way of examining the trend in gender balance by displaying the total numbers of women and men in the images we examined. Here, the unit of analysis was the person. Although the absolute counts differ across the right and left columns, the percentage patterns in the two panels are nearly identical, and the total number of women remains below parity in the latest cohort (43.3% for the 1990s and 2000s). We were conscious of the fact that one or two books could potentially contribute disproportionate numbers of either males or females, but we found that, in the last two decades, the basic pattern of Table 1 is replicated in each and every textbook. Thus, overall, we find strong support for hypothesis one.

A second way of thinking about tokenism is that women may simply be added to images to ensure a more robust representation that helps publishers pass the scrutiny of screening committees. Here, we moved beyond simple counts of women and men, the modal practice in the research literature, by examining actual gender roles in which men and women are depicted. While the number of women and men in pictures may be more balanced in recent decades, the question of how the sexes are portrayed in those images still needs to be addressed. For example, both over time and in the most recent period, men outnumber women in leading experiments. Similarly, more male than female doctors are portrayed, and there are more female nurses (and no male nurses!). Our second hypothesis directly tests the symmetry in gender roles by asking about the number of women and men portrayed in positions of authority, engaged in doing science, and as scientists. Here, again, the unit of analysis was the image. This is arguably the most persuasive test of the role-modelling argument. The analysis of the context in which males and females are depicted provides insight into the qualitative changes in gender representation across time.

We explicitly coded images for portrayals of power and, in those images which depicted authority relations, we coded for whether it was men or women, or both, who occupied the authority positions. Across all three cohorts there were 174 images that clearly depicted relations of power. In almost two-thirds of those images, men occupied the authority position. In all three time periods, men were more likely to be cast in positions of authority, including in the most recent decades where men are represented in 70% of the authority roles.

Table 2. Percentages of Women and Men in Positions of Authority in School Textbooks across Three Cohorts (1950s to 2000s).

	Total	Males and Females in Positions of Authority				
		Male	%M		Female	%F
1950–1960s	82	48	59		34	41
1970–1980s	21	20	95		1	5
1990–2000s	71	50	70		21	30
Total	174	118	68		56	32

Comparing the prevalence of women versus men in images of authority also revealed a subtler aspect of gender segregation in science. Men were not only shown more often in authority roles but were also portrayed in a wider array of authoritative positions (not shown in a table). This is, in part, due to the greater number of men in images of authority—depicting more men in these roles automatically increases their chances of appearing in a variety of authoritarian positions. However, even controlling for the disproportionate numbers, we found that women tend to be depicted in more circumscribed authority positions than men. For example, only men were depicted as orchestra directors, ship captains, presidents, Nobel Prize recipients, and even giants. Women, on the other hand, even when in authority, were mostly depicted as mothers, teachers, and nurses and, in the latest years, as physicians and lab technicians. This is strong support for the idea that, while gender balance may be improving, the representation of women in gendered roles has not been as progressive.

A second test of our differential gender-role hypothesis comes from examining images in which people are depicted as "doing science." When coding images that show students, teachers, and scientists actively practising science, we found that the trend is toward a greater balance in role modelling. In images highlighting active engagement with the practice of science, the gender balance has improved over time such that now—in images of people doing science—women are depicted 45% of the time and men 55% of the time.

Table 3. Percentages of Women and Men Engaged in "doing science" in School Textbooks across Three Cohorts (1950s to 2000s).

	Total	Males and Females Doing Science				
		Male	%M		Female	%F
1950–1960s	109	70	64		39	36
1970–1980s	80	55	69		25	31
1990–2000s	440	241	55		199	45
Total	629	366	58		263	42

Once again, however, much as was the case with authority positions, when we looked at the diversity of roles that men and women occupy, we saw that women were portrayed in a more concentrated number of roles. For example, only males were found in the categories "leading experiments," "using industrial machinery," "using a lie detector," and "working on excavations." What is especially noteworthy is that 87% of the females depicted as doing science in the latest 1990s–2000s cohort were students doing school experiments. Having images of girls participating in science experiments in school is important, but this representation needs to be balanced with more images of women engaged as scientists or in positions of authority in science.

Our last assessment of gender-role differences is an examination of the respective numbers of actual male and female scientists shown in textbooks. As evidenced in Table 4, there were no female scientists shown in the textbooks in either the 1950s–1960s or the 1970s–1980s. In the 1990s–2000s cohort, female scientists represent 25% of all scientists portrayed (and make up 23% of the scientists identified by name).

Table 4. Percentages of Female and Male Scientists Shown in School Textbooks across Three Cohorts (1950s to 2000s).

	Total	Males and Females Shown as Scientists				
		Male	%M		Female	%F
1950–1960s	16	16	100		0	0
1970–1980s	63	63	100		0	0
1990–2000s	81	61	75		20	25

Reviewing the depiction of scientists reveals subtle ways in which gender messages get transmitted. In *BC Science 8* (McGraw-Hill Ryerson, 2006; see Appendix 1), five science careers were highlighted, three of them involving women (as a meteorologist, an oceanographer, and a physician; male vignettes focus on divers and concert-lighting designers). A balance is sought even if the occupations may not all be scientific. This pattern was replicated in other recent texts. However, when it comes to the prestige of knighthoods and Nobel Prizes, men were highlighted (e.g., Sir Isaac Newton and Dr. Vitaly Ginzburg) and women were invisible. Clearly, the association of women and men with science is differentially valorized or, as we note below, gendered frames highlight men and women in significantly different ways.

Consistent with our observations above about men being in a greater diversity of positions, and women being concentrated in a few positions, a similar finding occurred for scientific roles. When women were portrayed as scientists, it is most often the case that their particular scientific expertise was not specified, although occasionally they would be shown as meteorologists, pharmacologists, or biologists. In contrast, men were much more likely to be identified as physicists or chemists, with their specialization and expertise being carefully signalled to readers, and their scientific occupations being labelled in much more diverse ways than was the case for women.

Finally, we extend this discussion of gender-role differences to show ways that gender is used to frame discussions of science (hypothesis three). Here, we rely on an example of how the eleven systems of the human body were portrayed. In previous eras, only male bodies were used in illustrating these systems. This has changed more recently (1990s and 2000s), although, as we will show, the ways in which gender is used to frame these bodily systems favours men. In Chapter 2 of *BC Science 8*, the biological functions of the human body are divided into the 11 standard systems typically described in middle-school texts. These systems are represented by 10 human figures (one for each system except for the excretory and respiratory systems which are illustrated together in one figure.) An equal number of female and male bodies are depicted in these 10 illustrations. The choice as to which body to use to illustrate which system, however, is clearly gendered. We reproduce the basic divisions in Table 5.

Table 5. Gendered Depictions of the Human Body, circa 2000s.

	Systems of the Human Body	**Image Depicted as**	
		Male	**Female**
1	Endocrine	"Manufactures and releases hormones"	
2	Reproductive		"Includes reproductive organs for producing offspring"
3	Integumentary		"Includes skin, hair, and nails. Creates a waterproof protective barrier …"
4	Skeletal	"Supports, protects, and works with muscles to move parts of the body"	
5	Muscular	"Has muscles that work with the bones to move parts of the body"	
6	Nervous		"Detects changes in environment and signals these to the body …"
7	Circulatory		"Transports blood, nutrients (chemicals need for survival) gases, and wastes"
8	Digestive		"Takes in food. Breaks down food. Absorbs …"
9	Immune	"Defends the body against infection"	
10	Excretory & Respiration	"Controls breathing …" "Removes liquid and gas …"	

Source: *BC Science 8* (McGraw-Hill Ryerson, 2006)

The second image on the page, coming just below the male body depicting the endocrine system, is a female body portraying the reproductive system. If any bodily system requires two diagrams, it is surely the reproductive system. The failure to include the male reproductive system sends a clear message—reproduction is a female issue.

The word choices in the two columns of Table 5 also stood out for us. In the male column, words like "manufactures," "supports," "defends," and "controls," stand in contrast to the female column, which features words such as "includes," "detects," "transports," and "takes in." Male images are much more likely to be described as active (e.g., skeletal system), whereas the bodily systems illustrated by female bodies (e.g., integumentary) are most often portrayed as passive systems. Furthermore, the skeletal system, for example, is not only active, but it also "works," "protects," and "supports," whereas the integumentary system is not only more passive by nature but it is described in the language of a hair salon advertisement: "skin, hair, and nails." Other gendered depictions on these pages relate to the circulatory and digestive systems, both of which are illustrated in female bodies with their functions and descriptions focused on food and nutrients. Feeding and nurturing are traditional female roles and, more specifically, motherly roles. The muscular system, in contrast, is portrayed by a male body. Much as was found in the previously mentioned representation of the skeletal system by the male body, the key physical roles of human strength, movement, and action belong to the muscular system. This finding is consistent with our third hypothesis and illustrates precisely the types of "gender schemas and stereotypes" to which the Council of Academies (2012, p. 41) alluded.

Discussion and Conclusion

We examined role modelling in three related guises—as gender balance, gender roles, and gender framing. Overall, as anticipated in our hypotheses, a shift toward gender equality has occurred between the 1950s and the present. This conclusion is strongest when we focus solely on gender balance in textbook images. With respect to gender roles we found two important results: first, men are more likely than women to be featured in prominent positions (e.g., as prize winners, in positions of authority); and second, women are shown in a more delimited range of roles than are men. With gender framing we found that content is still framed in ways that valorize masculinity (e.g., in depictions of the systems of the body). Gender equality has improved in science textbook representation, but the push toward equality requires more effort.

Depicting specific roles using only one gender and not the other reinforces the myth that men and women are essentially different, possessing different interests and skills, and, as a result, belonging in different roles. This type of gender segregation contributes to the commonly held idea that some roles are "for men" while others are "for women." The stereotypes thus promoted inhibit women from pursuing careers in male-dominated fields. In addition, the historical devaluation of traditionally female activities (England, 2010) —which persists in the way we assign value through salary and prestige to women—discourages men from pursuing traditionally female careers. Equality is bidirectional. Therefore, the reasons why women are underrepresented in STEM fields are closely related to the reasons why men are underrepresented in traditionally female fields (Charles & Grusky, 2004).

Why exactly we found more progressive change in the gender balance of images than we did for gender roles and gender framing is open to speculation. Certainly the push for more female role models in science has had good success, as textbook authors have clearly moved to address balance. Textbooks continue to be plagued, however, by the delimited cultural framing that says certain gender roles are appropriate solely to women or solely to men. Using a perspective of scientific objectivity, it makes sense that since women less frequently win Nobel Prizes or knighthoods in science, they should not be represented as having done so with equal frequency. But it also makes sense, when using a perspective of human rights and gender equity, to make substantive efforts to portray women in a diversity of positive and authoritative roles in the various fields of science. Most science textbook authors appear to subscribe almost exclusively to the former scientific objectivity perspective while showing less appreciation for the human-rights, gender-equity framework (Mendick & Moreau, 2013). Rebalancing this to construct a more equitable gender framing is essential. The two perspectives need not be oppositional. Indeed, positive change will only come once the dual perspectives of gender equity and scientific objectivity are openly embraced by science teachers and by those who design the science curricula. More precisely, it is in documents such as the *Common Framework of Science Learning Outcomes* (Council of Ministers of Education, Canada, 1997) that both perspectives need to be promoted (but where, unfortunately, the scientific objectivity paradigm continues to dominate, almost to the total exclusion of equity issues.)

Importantly, this is not simply an issue of getting science education right. Redressing the gender balance in STEM fields requires progress in multiple contexts. Here, the research by Croft et al. (2014) that we cited above is germane. They demonstrated that the gender-role balance in one context (the household) has ramifications for daughters well beyond the domestic sphere by influencing career aspirations. Context matters in schools, too, and recent research has demonstrated that when the gender balance is more equitable across multiple school settings (e.g., in extra-curricular activities), then the likelihood of girls choosing to pursue STEM fields is enhanced (Legewie & DiPrete, 2014).

Contrary to the NSERC (2010, p. 13) implication, it is not simply "a lack of female role models in science and engineering" that is the problem. Our data show that role modelling needs to be understood more holistically than is often the case. Simply adding women is insufficient. A more nuanced and full-blown framing of role modelling and representation would include sensitivity to, and promotion of, the following: more women need to be represented, and in more diverse roles, including roles of authority and action, in ways that stress their inclusion in all forms of scientific practice. This effort also requires the incorporation of teaching styles in science that relate better to learning styles favoured by many girls. These would include having more in-class discussions, cooperative learning techniques (e.g., collaboration through group projects), the demonstration of people-helping facets of science and technology careers, and an emphasis on the ways science can improve the quality of life for all living things. This would also include placing more emphasis on the social relevance and practical applications of science and less emphasis on experiments and scientific results, especially those that tend to have applications of direct benefit to industry and the military (Baker, 2013; Cech, 2014; Dasgupta & Stout, 2014).

Studies of gender representation, like ours, have typically focused on isolated cases—textbooks, video games, colouring books, and so forth. The next generation of research in this area needs to pick up on what our earlier reference to *The Big Bang Theory* implied. Career trajectories are influenced by a myriad of representational dynamics across an array of cases. How gender representation may or may not be changing across this full range is an important research question to pursue.

Change needs to occur well beyond the school text and the classroom; it must extend to the ways in which the culture of science itself is promoted (Gonsalves, 2014). Women in science need to be shown doing things to which many girls will relate, and the social benefits of scientific practice and the ability to effect positive change need to be stressed; opportunities need to be promoted for girls to participate in informal science learning, such as science fairs, science camps, science workshops, and community science events; and opportunities need to be provided to make women in science more visible in communities and schools. Chris Hadfield (Canadian Space Agency) and Bob McDonald (CBC) have done tremendous service to the promotion of science in Canada, but we desperately need to profile more women who can champion science, like astronaut Roberta Bondar. Without scientific mentors and models to emulate, in textbooks and more broadly, it will be difficult to close the gender gap in STEM fields. We stress that an exclusive focus on science is not the answer but, rather, a broader, more progressive balance of gender in other contexts is needed if more women are to be encouraged to pursue STEM careers.

Appendix 1: List of Textbooks Analyzed

	Book	Authors	Publisher	Year Published	Grades
1	Exploring Science: Six	Thurber, W.	Toronto, ON: Macmillan	1957	7
2	You're Growing Up: Guidebook for Health and Personal Development, Book 7	Shacter, Helen and others	Toronto, ON: Gage	1951	7
3	Using Science	Smith, Victor C., Trafton, Gilbert H.	Chicago, IL: Lippincott.	1946	7
4	Uses of Science	Limpus, George H., and others	Toronto, ON: MacMillan	1951	8
5	Mastering Our Environ-ment	English, H.O.	Toronto, ON: Dent	1952	9
6	Science and Life	English, H.O., and others	Toronto, ON: Dent	1941	9 & 10
7	Modern Biology	Otto, James H., and others	Toronto, ON: Clarke, Irwin & Co.	1954	10 & 11
8	Explorations in Science	George H. Limpus, and others	Toronto, ON: Macmillan	1951	7
9	Reading about Science 1	Anastasiou, Clif-ford J.	Toronto, ON: Holt, Rinehart and Winston	1968	8, 9 & 10
10	Developing Science Con-cepts in the Laboratory	Rasmussen, Walter H., Schmid, Man-fred C.	Scarborough, ON: Prentice-Hall	1968	9 & 10
11	Reading about Science 2, BC Edition	Foster et al.	Toronto, ON: Holt, Rinehart and Win-ston	1969	9 & 10
12	Introducing Science Con-cepts in the Laboratory	Schmid, Manfred C. Jewell, Dennis E.	Scarborough, ON: Prentice-Hall of Canada	1973	8
13	Introducing Science Con-cepts in the Laboratory	Jewell, Dennis E. and others	Scarborough, ON: Prentice-Hall of Canada	1977	10
14	Biological Science: An Inquiry into Life	Meyer, Don E. (ed.)	New York, NY: Harcourt, Brace & World Inc.	1963	11 & 12

	Book	Authors	Publisher	Year Published	Grades
15	High School Biology: BSCS Green Version	Biological Sciences Curriculum Study	Chicago, IL: Rand McNally	1963	11 & 12
16	Botany: An Introduction to Plant Biology	Weier, T. and others	New York, NY: Wiley	1974	11 & 12
17	Algae in Water Supplies: An Illustrated Manual on the Identification, Significance, and Control of Algae in Water Supplies	Palmer, Charles Mervin	Cincinnati, OH: U.S. Dept. of Health, Education, and Welfare, Public Health Service	1959	11 & 12
18	Science Probe 8	Bullard, Jean	Toronto, ON: J. Wiley & Sons Canada	1985	8
19	Science Probe 8	Baumann, Frank	Scarborough, ON: Nelson Canada	1994	8
20	Science Probe 9	Bullard, Jean	Rexdale, ON: John Wiley & Sons	1993	9
21	BC Science 7	Mason, Adrienne, Anderson, Elspeth	Toronto, ON: McGraw-Hill Ryerson	2004	7
22	BC Science 8	Sandner, Lionel	Toronto, ON: McGraw-Hill Ryerson	2006	8
23	BC Science 9	Sandner, Lionel	Toronto, ON: McGraw-Hill Ryerson	2007	9

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