

A Social Semiotic Analysis of Gender Representations in Biology Textbooks for Upper Secondary Schools in China

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Abstract

The gender gap remains an issue in the biological education community. This study explores the extent to which an egalitarian gender ideology, encapsulated in five biological science textbooks for upper secondary schools in China, manifests through representational, interactive and compositional meanings of social semiotic theory. The findings reveal that females in the textbooks tend to be depicted as passive and inferior to males. More males are represented as playing pioneering and leading roles, as opposed to females, who are cast in assistant and subordinate roles in professional activities. The gendered messages delivered have the potential to disempower female students' career aspirations and adversely regulate their perceptions and projections of gender identities in biological science.

Keywords: gender representation; biology textbooks; secondary school; social semiotics



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Introduction

Gender equity has been an enduring issue in science and science education. Richardson (2013) notes that science, as a proxy, functions as both an embodiment and a reproductive form of gender inequity. Such gender inequity in science may spring from a gender-essentialist ideology (Charles and Bradley 2009). The gendered value systems, influential in casting, reinforcing and reproducing gender-normative stereotypes, have underplayed the contributions made by women to science-related fields (Lodge and Reiss 2021).

According to data from UNESCO (2019), the average share of female researchers in science-related fields is 18.5% for South and West Asia, which is significantly lower than in North America and Western Europe, where it is 32.7%. Even though the decline in participation in science is less evident in developing than developed countries (Bøe et al. 2011), the country-specific statistics show that females are gravely marginalised as researchers in scientific fields in some developing countries.

The gender ideology and women's identities in China differ from those in developed countries, since China is a conservative and patriarchal society that traditionally subjects women to a subordinate and submissive position. Yet, it spares no expense in seeking gender equity and improving the social status of women. Hence, there are different social forces at play competing to maintain and reconfigure gender ideology. As such, the visuals in school textbooks are worth studying since they reveal how school textbooks reflect narratives of gender ideology of the social forces through the manipulation of the visual relations of men and women in textbooks' illustrations (Apple 1993; Apple and Christian-Smith 1991; Williams 2006). Considering the critical role that school textbooks play in students' understanding of what is appropriate for their construction of gender identity and that gender representation in biological science textbooks is under-researched, this article intends to enquire into the extent to which the illustrations in Chinese biological science textbooks for upper secondary schools convey an egalitarian gender ideology.

Gender Ideology in China

Gender ideology refers to a system of beliefs and values that defines and justifies the differential and distinctive roles of women and men in a society, and moulds individuals' appreciation of what are acceptable roles and behaviours for males and females (Berkman, Kawachi, and Glymour 2014; Brannon 2005; Butler 2004; Greenstein 1996; Levant and Richmond 2016). As China has long been deeply rooted in a conservative and patriarchal culture, the gender ideology in China is traditionally characterised by a polarised perspective on gender, with men and women symbolised, respectively, in roles of supremacy versus subordination, centrality versus marginality, independence versus dependence, and activeness versus passiveness. Such a polarised gender perspective dictates that men and women act in accordance with the endorsed roles and responsibilities in both private and public spheres, and obstructs women from moving

to a higher rung of the social ladder. Since the founding of the People's Republic of China (PRC) in 1949, there has been a commitment to an egalitarian gender ideology, and it has been vehemently invoked as part of social reform to abolish the feudal system that confined women to a state of servitude. Legislation was enacted to grant women more freedoms, such as mate selection and work opportunities (Davin 1976; Pimentel 2006). Women's access to social space was broadened as women were entitled to join the work perceived as masculine. In spite of the progress in gender equity and the emancipation of women during the early period of the PRC (1949–1965), these policies were not radically implemented until the Cultural Revolution (Pimentel 2006). The political movement of the 10-year Cultural Revolution berated gender inequalities and attributed the oppressed status of women to the social, cultural and historical constructs that disadvantaged women rather than the biological differences between the two sexes (Pimentel 2006). The movement advocated that the gender ideology upholding women's role of doing household work and the status of subjugation to men should be radically changed and that women should be endowed with equal rights as men to participate in work. The period of the Cultural Revolution radicalised and pushed forward the egalitarian gender ideology that was not fully realised in the early stage of the PRC (Pimentel 2006). The advancement of gender equity in the period was forwarded by the will of the state and charismatic leaders, primarily Chairman Mao, in a top-down manner through the national political apparatuses. Such promotion of gender equity differs from the approach adopted in Western countries where achieving women's equal status with men was mainly driven by civil movements.

While the Cultural Revolution fruitfully advanced the equal gender ideology to an unprecedented level, the progress in gender equity could not be immune to the historical and cultural constraints. Without substantial changes to the cultural norms and attitudes biased against women at the grassroots level, the top-down political movement failed to fully ingrain the equal gender ideology in the general public in practice. A few years after the Cultural Revolution, China initiated the socioeconomic reform (1980–1991), which brought about huge social and economic changes, opening up more educational and occupational opportunities for women. However, the reform did not seem to engender much progress in equal gender ideology or women's status. Instead, the traditional gender ideology resurged with the call by men to send women back home due to the increased competition from women participating in the labour market. In 1994, the Chinese central government was determined to radically convert the planned economy to a market economy. From then on, the gender discourse has been negotiated between the state, which advocates an egalitarian gender ideology, and the market logic, which accentuates individual competence, productivity, efficiency and women's traditional roles (Ji and Wu 2018). Although the state was active in promoting an equal gender ideology, in practice gender discrimination against women has been exacerbated (He and Wu 2017; Li and Ma 2006; Li and Xie 2015; Shu 2005). Women are more likely to be laid off because the market logic tends to perceive that productive efficiency will be compromised due to women's childcare and other familial obligations. The rapid modernisation in China brought about by the market economy should have elevated

gender equality. Regrettably, a more equal gender ideology did not accompany China's rapid economic development. The state logic and the market logic are often at odds regarding women's equal status with men. This leads to the complex dynamics of the state and the market logic competing to navigate the narratives of gender ideology in contemporary Chinese society as well as in school textbooks.

Gender Representations in Science-Related Textbooks

Previous literature from a number of countries across geographies reveals that science textbooks tend to have an androcentric visual presentation of gender (Elgar 1999; Kahveci 2010; Sunar 2012). In analysing the visual images in science textbooks, Walford (1980) found that there were twice as many representations of men compared to women, implicitly transmitting a masculine face of science. In an examination of chemistry textbooks, Bazler and Simonis (1991) show that the pictures of males were still dominant even though the gender ratio between men and women presented in the textbooks had been improved. Similarly, Potter and Rosser's (1992) study on life science textbooks reports that males significantly outnumbered females in textbook illustrations. Elgar (2004) further notes that a huge disparity in gender representations is prevalent in textbooks, with males being portrayed in more prominent roles and women being displayed primarily in traditional roles of household chores.

Although recent work suggests that positive progress has been made to mitigate the visual gender inequality in science textbooks (Baker 2016), there are a number of hidden ways that favour males over females by depicting women in powerless and low-status positions and activities. As Parkin and Mackenzie's (2017, 35) study indicates, science textbooks hide the strong male bias while feeding unconscious biases to students despite the textbooks pretending to be gender neutral. Moreover, they continue exhibiting what Bourdieu (2009) terms masculine domination. In the aforementioned literature, females are generally portrayed in ways that embody the established ideology of gender inequity to transmit gender norms endorsed by the society. These images in the textbooks may leave girl students with the impression that science is reserved for males and may thus damage their appreciation of and engagement in science-related fields.

Many studies on gender representations in textbooks have been conducted in China, primarily focusing on gender disparities in particular subjects such as English, history and mathematics at specific education levels. In the Chinese mainland, the most impactful research on gender representations in textbooks was supported by the Ford Foundation in the early 2000s (Yuan 2013). In 2001, the Ford Education Fund organised over 20 researchers in China to help eliminate gender bias in textbooks and conducted a comprehensive survey of gender stereotypes in textbooks used throughout the country (Shi and Ross 2002). The primary fruit of the research was the publication of *Into the Gendered World in Textbooks and Teaching* (Shi 2004), which contained 19 studies on gender issues in textbooks and related instructional materials used in kindergarten, primary and secondary schools. The publication unveiled a substantial underrepresentation of women in the texts' characters and a tendency to cast those

women in stereotypical roles (Shi 2004). While the research and subsequent studies have covered many subjects at different education levels, gender representation in biological science textbooks in China is under-researched. The limited studies on science-related textbooks in China reveal that gender stereotypes and gender inequality persist. Stereotypical images suggesting that science is more suitable for boys and art for girls are implicitly endorsed by the textbooks (Jiang 2022; Tang, Chen, and Zhang 2010). Despite exposing gender bias in descriptions of men and women, these textbook studies mainly employed research methods relating to quantitative content analysis of texts and classroom observation. Social semiotics has rarely been utilised to examine the visual images in textbooks in China, particularly biological science textbooks.

Social Semiotic Framework

Semiotics is generally defined as the study of the meaning conveyed by forms such as symbols and signs. As a division of semiotics, social semiotics not only attends to signs, but also to the meaning-making process of how people construct and communicate meaning in relation to specific social contexts (Thibault 2004, 68). In the late 1980s, Kress and Van Leeuwen started to frame a social semiotic approach to reading visuals in their book titled *Reading Images: The Grammar of Visual Design*. Kress and Van Leeuwen propose that signs and images laden with values and meanings can be interpreted within a social and cultural context. They draw on Halliday's (1978) systemic functional perspective, which posits that language as a resource for communication is functional rather than formal, and it serves synchronously three metafunctions, which are ideational (the experiences represented), interpersonal (social interactions and relationships enacted), and textual (coherent messages organised). Kress and Van Leeuwen (2006) adapted the three metafunctions to representational (expressing the experiential world), interactive (interacting with viewers) and compositional meanings (arranging visual elements) to analyse visuals. Kress and Van Leeuwen (2006, 19) note that while visual and linguistic modes differ in their specific forms and the way in which the meaning potential is realised, language and visual communication can both be capitalised on to realise the same fundamental systems of meaning that constitute our cultures.

Representational Meaning

Representational meaning deals with the way human experiences are expressed in visual images. Kress and Van Leeuwen (2006) point out that in analysing visual images, one should attend to two types of participants, that is, represented participants and interactive participants. The represented participants are the elements depicted in visual images such as the people, places and things, whereas the interactive participants are those people who produce or view images and interact through visual images. The relations, interactions and connections of the depicted elements in visual images are realised by vectors, which are presented explicitly or implicitly as a visible or invisible directional line such as oblique or diagonal lines. Kress and Van Leeuwen (2006) postulate two types of representation structure, that is, narrative structure and conceptual

structure. The narrative structure relates to unfolding actions and events, relations, processes of change, and transitory spatial arrangements, while conceptual structure has to do with the representation of participants in terms of the generalised, stable and timeless essence of the depicted elements (Kress and Van Leeuwen 2006, 59). The narrative structure is embodied by vectors, directional lines formed by, for example, eyelines or the stretch of an arm, to connect the participants in a transactional or non-transactional process of action. Depending on vector types and participants, the narrative structure can be an action or reactional process. The action process denotes a vector formed by a depicted element or an arrow emanating from a participant, while reactional processes are associated with vectors formed by the eyebeams of one or more represented participants.

Interactive Meaning

Interactive meaning explores the relations between the represented participants and interactive participants (the producers and viewers of visual images). It concerns three kinds of relations: the relations among represented participants, the relations among interactive and represented participants, and the relations among interactive participants. The realisation of these various relations relies on four elements, namely, contact, social distance, attitudes and modality. Contact is constructed through the gaze interaction between represented participants and viewers. It can be divided into two categories: demand (the represented participants demand a response from viewers by gazing at the viewers) and offer (the represented participants gaze away from viewers and serve as objects for the viewers to contemplate). Social distance, representing the relations between the represented and interactive participants, is realised by different frame sizes ranging from close, medium to long shots to depict an intimate, social or impersonal relationship between the represented participants and viewers. Attitudes refer to the creation of different relations between the represented participants and viewers through the selection of an angle. A horizontal angle can be manifested with a frontal angle or an oblique angle that respectively connotes involvement or detachment of the represented participants with the viewer. A vertical angle can be manipulated to indicate the power relations between the viewer and the represented participant; whether the represented participant is seen from a high angle, an eye-level angle or a low angle by the viewer suggests three different power relations, namely, viewer power, equal power and represented participant power.

Compositional Meaning

Compositional meaning has to do with how the representational and interactive elements are placed and arranged to cohere into a meaningful whole. The compositional meaning is expressed through three interrelated systems: informative value, salience and framing. Information value is related to the placement of elements and the values attached to the elements in various zones in an image. As Kress and Van Leeuwen (2006) note, the elements placed on the left and right are supposed to provide given (known) and new information while those at the top and bottom are interpreted as ideal and

factual information. Saliency is correlated with the way in which certain pictorial elements are modulated to stand out so as to draw viewers' attention. For example, the elements in the foreground are more prominent than those in the background to attract attention from viewers. Saliency is realised through relative size, sharpness of focus and colour contrast, among others.

Textbook Selection

In the Chinese textbook market, multiple versions of biological science textbooks written by different publishers are available. Currently, the People's Education Press (PEP) takes up the largest share of the textbook market in mainland China. According to Ming (2011), the adoption rate of the textbooks by the PEP was over 50%. The textbooks analysed in this study are solely from the PEP as its textbooks are the most widely adopted. Specifically, five biological science textbooks, namely, *Molecules and Cells*, *Genetics and Evolution*, *Homeostasis and Regulation*, *Organisms and Environment*, and *Biotechnology and Engineering* (Curriculum and Textbook Research Institute 2019) written for upper secondary schools were selected for this study.

Analysis Approaches

The approaches employed in this study are social semiotics in combination with content analysis to assess whether gender is equally represented in the illustrations of these textbooks. Some scholars argue that semiotic analysis can be less valid due to its reliance on subjectivity. However, previous studies (Bell and Milic 2002; Goffman 1976) justify the effectiveness of semiotic analysis in analysing gender issues in visual images when it is employed in conjunction with content analysis, a technique used for making valid and replicable inferences from a systematic scrutiny of meaningful matter (Krippendorff 2004). The content analysis helps categorise, interpret, quantify and extract themes from data (Reinharz 1992).

In this study, content analysis was performed to provide counts of males and females in the textbooks through an examination of the individuals in photos and pictures. The gender of most individuals in the illustrations of the textbooks can be identified by means of their cultural and physical body attributes such as clothes, body profile, hairstyles and facial features. However, the gender of some illustrated individuals cannot be verified due to small and blurry figures, protective clothes, helmets or masks. These individuals were excluded from the analysis. The individuals illustrated in the textbooks were quantified to determine the total number of males and females and then coded by the authors. We first conducted a pilot coding of the individuals in the illustrations to predetermine the criteria to distinguish what makes an illustrated individual feminine or masculine. After the pilot coding, we discussed our differences in our coding and reconciled to establish final criteria based on the features exclusive to feminine or masculine gender to ensure that we were consistent and robust in the classification of all individuals in the illustrations. The tallies for the counts of feminine or masculine individuals were noted down.

Social semiotic analysis was performed by applying the three metafunctions of representational, interactive and compositional meanings developed by Kress and Van Leeuwen (2006) to critically examine the represented participants in the illustrations of the textbooks. Four subdimensions are contained in the representational meaning of the participants in the visual images: actors (participants imposing actions on another participant), reactors (participants' reactions to another participant's actions), goal (the aim of another participant's actions) and expressors (participants' non-transitive actions). With respect to the interactive meaning of the visual images, the subdimensions of gaze interaction, social distance and attitudes were established by Kress and Van Leeuwen (2006). Two categories of gaze were coded: demand and offer. Social distance was coded in terms of three levels, that is, intimate relationship, social relationship and impersonal relationship between participants and viewers. Attitude is achieved by two types of angles of interaction: horizontal and vertical angles. The horizontal angle can be frontal when participants are positioned in front of the vanishing points or oblique when participants are situated to the left or right of the vanishing points (Bell and Milic 2002). The frontal and oblique angles signify the involvement and detachment on the part of viewers. A vertical angle is realised by different heights of viewpoint in relation to participants. A high angle in which participants are shown from above suggests the participants are insignificant and less powerful than the viewer, while a low angle in which participants are shown from below implies that the participants are more powerful and superior to viewers. Participants presented in a high and low angle were coded high and low respectively, and those at the horizontal level were coded as medium. As to the compositional meaning of the visual images, two subdimensions relating to information value and salience were coded. Information value is concerned with the left-right and top-bottom placement that corresponds to given-new and ideal-real information. Salience is achieved by a number of means such as foreground or background placement, size and colour contrast to draw viewers' attention.

Findings

Of the 119 individuals depicted in the textbooks whose gender was distinguishable, 82 and 37 individuals are males and females, respectively, as shown in Table 1. The result of a chi-square test indicates a statistically significant difference ($\chi^2 = 17.02$; $df = 1$; $p < 0.001$) in the representation of the two sexes in the textbooks, with males being overrepresented, demonstrating that gender equality has not been met. This lack of equality is further highlighted by the portrayals of females in mostly non-professional or assistant roles, with only 7 out of 37 depicted in professional biology-related research positions.

Table 1: Distribution of illustrated individuals by gender

Total discernable individuals	Male	Female
119	82	37

Representational Meaning

The data in Table 2 indicate the relations between the participants' gender and their narrative roles. There is no significant difference in the representation of actors between the male and female individuals illustrated in the textbooks ($\chi^2 = 0.25$, $df = 1$, $p > 0.05$). However, a significant difference is observed in the representation of goals between males and females ($\chi^2 = 8.05$, $df = 1$, $p < 0.05$), suggesting that females are more likely to be depicted as the target of other participants' actions than males.

Table 2: Distribution of narrative representation of participants by gender

	Actor	Goal	Expressor	Reacter
Male	47	1	24	10
Female	23	5	8	1

As shown in Figure 1, the nurse and the patient (young girl) are the represented participants in the photo. The plunger of the syringe pushed by the nurse form a vector directed at the arm of the patient, suggesting that the nurse is performing actions on the patient. Thus, the nurse is the actor of a transactional action process in which the patient is the goal. The nurse is shown actively involved in a narrative representation, implicitly conveying the gendered stereotype that nursing befits women. The data regarding the representation of expressor ($\chi^2 = 1.04$, $df = 1$, $p > 0.05$) and reacter ($\chi^2 = 2.74$, $df = 1$, $p > 0.05$) show no statistically significant differences between males and females in terms of expressing emotions and reacting to actions, suggesting they were as likely to be depicted by males as by females. These findings disagree with Lodge and Reiss's (2021) finding that males are more likely to be the target of actions and that females are more likely to be emotional.



Figure 1: A nurse injecting a patient

Interactive Meaning

Table 3 lists the data for the angle of gaze of represented participants by gender in the textbooks. The chi-square test reveals that there is no statistically significant difference ($\chi^2 = 4.07$, $df = 2$, $p > 0.05$) in the representations of the angle of gaze between males and females. Interestingly, the finding contradicts Lodge and Reiss's (2021) study in which females were found to look away from the camera more frequently than males and Dyer's (1992) assertion that men are less likely to face the camera because this action is viewed as being passive. The differences among the literature may stem from specific cultures. In a Chinese cultural context, gazing directly at people is regarded as being aggressive rather than what Bailey (2002) claims as hegemonic masculinity regardless of gender in most cases, and it is not encouraged to look at people as if demanding something.

Table 3: Distribution of gaze of represented participants by gender

	Demand	Offer	No gaze
Male	9	70	3
Female	1	32	4

As shown in Figure 2, a visual demand is achieved when the two men in the picture directly gaze at the viewer. The direct gaze creates a vector and a form of direct address that connects the two men with the viewer. By doing so, they seem to demand some response from or imaginary relation with the viewer, making the picture more persuasive. The smiling facial expression of the men may invite the viewer to enter into an affinity relation with them.



Figure 2: Frederick Banting and Charles Best with a dog treated with insulin

The majority of the females and males tend to be depicted as being oblique to the viewer (Table 4), indicating that the represented participants have a high level of detachment since an oblique angle represents detachment from the viewer, according to Kress and Van Leeuwen (2006). However, the chi-square test demonstrates that there is no statistically significant difference ($\chi^2 = 1.15$, $df = 1$, $p > 0.05$) in the representations of the horizontal angle between males and females in the textbooks. This finding suggests that the represented participants' gender is not correlated with frontal and oblique angles.

Table 4: Distribution of horizontal angle of represented participants by gender

	Frontal	Oblique
Male	28	54
Female	9	28

Figure 3 shows a man and a woman conducting research for genetically engineered drugs. The woman is photographed from an oblique angle, rendering the viewer detached from the woman. Moreover, although the woman is involved in a research activity, she merely plays an assistant role.



Figure 3: Researching genetically engineered drugs

The data regarding the participants' gender and the vertical angle are presented in Table 5. Few illustrations depict participants from a low angle, as indicated by Figure 2, in the textbooks. The two men in Figure 2 are looking down at the viewer, indicating the men have power over the viewer. There is no statistically significant difference ($\chi^2 = 1.00$, $df = 2$, $p > 0.05$) in the representations of the vertical angle between males and females, meaning that the two sexes are as likely as to be depicted using the three types of vertical angle. The majority of the female and male individuals are depicted from a medium or eye-level angle, suggesting an equal power relation between the represented participants and the viewer. In this regard, both sexes are on equal footing in being portrayed at a vertical angle.

Table 5: Distribution of portrayals of participants using a vertical angle by gender

	High	Medium	Low
Male	8	71	3
Female	3	34	0

According to Kress and Van Leeuwen (2006), the frame size in relation to participants can determine how close the participants in an image are to viewers, thereby producing the different degrees of social distance, from intimacy to impersonality, between the participants and viewers. In Figure 4, the woman in the picture is a malariologist who was the first female citizen in China to receive a Nobel Prize. She could serve as a successful model for female students to emulate. However, the picture makes the woman smaller against the large frame size of *artemisia annua* in the top-left zone. The imaginary distance achieved by the shot between the woman and the viewer creates a detached relation that lets the viewer feel far away from the woman. In this case, it

prevents the viewer from building an intimate relation with the woman, as the viewer is positioned at a far social distance. The social distance is manipulated to downplay the woman’s great contribution and influential role. The data in Table 6 show that there is no statistically significant difference ($\chi^2 = 0.67$, $df = 2$, $p > 0.05$) in the depictions of different degrees of social distance between males and females.

Table 6: Distribution of social distance of represented participants by gender

	Intimate	Social	Impersonal
Male	2	62	18
Female	1	26	10



Figure 4: The Nobel laureate is extracting artemisinin from artemisia annua

Compositional Meaning

There is a significant difference regarding the informational value in the four illustrations featuring females placed in the left zone of the illustrations and males in the right. According to Kress and Van Leeuwen (2006), the compositional meaning of females placed on the left side is considered as something given (known), whereas males on the right side are seen as something new (unknown). As such, the males in the right are perceived as being superior to females in terms of their informational value. As to the salience, there is no significant difference since merely three illustrations position one female and two males in the foreground. In this regard, the textbooks present gender equally in their illustrations.

Discussion

Textbooks play a key role in implicitly and explicitly transmitting messages about how science is conducted by men and women, and what specific role is projected in relation to their gender (Aladejana and Aladejana 2004; Elgar 2004). This study enquired into

how gender is represented in five Chinese biology textbooks widely adopted by upper secondary schools. The social semiotic analysis of the individuals in the illustrations reveals that females tend to be depicted as passive in terms of participants' actions more often than males. The implications of females represented as the goal suggest a tendency to depict them as passive participants engaging in roles of low social status.

With respect to the informational value of compositional meaning, the data in the study show that sex-specific differences regarding the left-right placement are pronounced. Females are more likely to be presented on the left side of the visual images, insinuating females are inferior to males, according to Kress and Van Leeuwen (2006). This is dissonant with Lodge and Reiss's (2021) study, which indicates that the left-right placement was not sensitive to participants' gender.

Since the social semiotic analysis suggests no significant differences in the presentation of male and female individuals as actors, expressors, or reactors, or related to gaze, horizontal and vertical angles, social distance and salience, it is tempting to draw the conclusion that gender inequality in the textbooks under examination has been ameliorated. However, content analysis suggests that a sexist ideology persists in the textbooks when one interrogates the subtle and nuanced strategies employed by the authors of textbooks in representing male and female individuals. For instance, although no significant difference is observed in framing the female and male individuals at a high angle in which the viewer towers over the represented participants, more male than female individuals shot at the same angle are portrayed as being active, pioneering and leading in their professional roles in scientific activities. According to Mburu and Nyagah (2012), the general criterion to judge whether textbooks are gender biased or gender neutral is the quantities of males and females illustrated. Since the frequency of females in the illustrations is significantly lower than that of males, it can be argued that the textbooks demonstrate an overt bias favouring males by including more representations of males despite the attempts made by the government to redress the gender gap.

This finding lends credence to Blumberg's (2008), Arslan Ozer, Karatas, and Ergun's (2019), and Parkin and Mackenzie's (2017) studies in which science textbooks tend to be in favour of men. The stark overrepresentation of males as opposed to the paucity of the representation of women, regardless of whether it is consciously or unconsciously done, may generate an impression for students that biological science is androcentric when students interact with the biology textbooks in their classroom. The preponderance of males in the illustrations may reflect the gender bias against women covertly or overtly practised in the biological science-related institutions or organisations of Chinese society, and supports Walford's (1980) description of masculine science. This masculine face may mediate how students see biological science in relation to their gender. Furthermore, the students' interaction with gender-biased messages transmitted by the textbooks may negatively regulate female students' aspirations regarding biological science.

Unlike previous studies showing that illustrations of females have been confined to domestic roles (Cohen and Cohen 1980; Elgar 1999), females in this study tend to be portrayed in a subordinate role to men or in roles that demand fewer professional skills and less knowledge. For instance, in many illustrations females are depicted as passive or as assisting in activities such as watching men do research work. In contrast, males are more likely to be illustrated as working with microscopes and being engaged in professional jobs with high status and reverence such as researchers and doctors. The depiction of females engaged in research activities or other professional work remains underrepresented. This treatment implicitly sanctions the superior role of males over females in biological science activities, resonating with the theory of gender hierarchy that hegemonic masculinity renders women subordinate to men (Connell and Messerschmidt 2005). In addition, the textbooks are replete with successful male models and there are few references to successful female role models for a girl student to follow. Even though successful females are presented, the textbooks tend to downplay them. For instance, a malariologist who was the first female citizen in China to receive a Nobel Prize could have been portrayed as a successful role model for female students. However, the textbooks fail to mention that she is a Nobel laureate and to provide any description or acknowledgement of her contribution to her research field. As such, this treatment by the textbook will not empower or motivate female students to emulate her and could mislead students into viewing the Nobel laureate as an average woman. Further, the Nobel laureate is photographed in a small frame size, which would distance the viewer from the woman, belittling successful females' roles in biological science. In this regard, such patterns of gender representation in these textbooks are consonant with those in previous studies that have unveiled gender partiality in the descriptions and portrayals of professional roles (Asriyama, Saleh, and Fitriati 2020; Bataineh 2020; Elgar 2004; Parkin and Mackenzie 2017).

The Chinese state makes every effort to promote gender equity and seeks fair representations of men and women in textbook writing. But the state's will is often compromised by the market logic, here mainly represented by the textbook writing and publishing market. This market is subject to the gender ideology held by the writers and institutions, many of whom are male biologists in male-dominated biology research institutions. The reasons for the writers and institutions to be biased against females are multiple. First, many of these male writers' or biologists' beliefs are rooted in Confucianism, which emphasises the ideas of a natural order where women are obedient to men according to the nature of the biological differences of the two sexes. Confucianism contains implicit biases against women that may lead to gender inequality and still influences many people in contemporary China. In the writing of school textbooks, it is inevitable that there will be some traditional prejudices against women. Second, some writers, biologists and biology research institutions believe that biology-related work is highly demanding both intellectually and physically, and they uphold the prejudice of women being less competitive in intellect and physical strength than men in biological work. Biological work is perceived to require high intellectual and physical abilities associated with being masculine, especially abilities required to

perform hard physical work. Lastly, some writers, biologists and biology research institutions assume that the sexual division of labour based on men's and women's respective innate biological faculties results in a complementarity that will maximise social productivity, thus naturalising and justifying gender inequality in biology-related work as a rational process.

In China, regulations and rules have been enacted to ensure gender equality in various fields, making sure that the rights and power of women are respected as equal to that of men. Unfortunately, these regulations and rules have been loosely administered, giving rise to the occurrence of gender inequality in textbook writing. That is to say, gender inequality in textbook writing will hardly be mitigated without a strong enforcement of the regulations. Instead, some writers, biologists and biology research institutions, mediated by the above-mentioned gendered ideology, may continue taking a gender biased approach. In sum, the state promotes gender equity in textbook writing. But the state's promotion of gender equity is neutralised by the writers, biologists and biology research institutions that hold a biased mindset and prejudice against women. This is how the state and the market logic (the textbook writing and publishing market) compete for maintaining and reconfiguring gender ideology in textbook writing.

Implications

The illustrations featuring males and females in textbooks will affect students' perceptions of what is considered appropriate for their gender in biological science. In part, the textbooks fail to provide a balanced gender representation by showing equal numbers of males and females as well as successful role models of both sexes. The subordinate roles in which women in the textbooks are portrayed, the quantitatively low representation of women and the few professional activities women are depicted as doing perpetuate gender stereotyping that downplays the contributions made by women. This may restrict the space for female students to perceive themselves as active players in biological science in the future and may mediate students' construction of gender identities in relation to biological science. If gender biases against women in the textbooks are accommodated by students, they may result in female students failing to realise their potential (Amerian and Esmaili 2015; Foroutan 2012). Unless the sexist ideology encapsulated in the illustrations is challenged, girls and women are less likely to consider themselves as an integral piece inseparable to the whole mosaic of biological science. As such, biological science teachers assume a critical role in mitigating gender biases in their class teaching. Biological science education practitioners should be sensitive to gender discrimination and gender biased issues, and they should help their students to read critically representations of female and male individuals in textbooks so that they will not be affected by the gender biased images. Moreover, textbooks should be free of stereotypes of gender roles for men and women, and the producers and publishers of textbooks should take proactive steps to give equal prominence to males and females in their visuals in terms of quantity, professional roles and successful role

models. In doing so, textbooks could encourage students to think that biological science has a wide range of career options for both sexes.

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