How textbook images frame the gender roles of women in science and elsewhere: a content analysis of elementary school science textbooks

Based on the concepts of gender framing and gender categorization, this content analysis evaluates the images of adults (N = 1655) and the portrayal of women from the 6 series of science textbooks authorized by the Japanese Ministry of Education for use in elementary school science classes in the 2022 academic year. The images were counted and coded according to the activities the participants were engaged in. Data were then analysed according to three potential patterns for transmission of gender roles – invisibility, low stature, and domesticity. The content analysis showed differences between the 6 series in terms of their portrayal of women and of female scientists, however, across all series, there were fewer women portrayed than men, fewer female scientists than male, and fewer women were presented as important 'people to study'. Women were less likely to be shown in high-status decision-making roles, as demonstrating 'brilliance', or as being rewarded or recognised for their scientific achievements. They were, however, more likely than men to be depicted in images connected to themes of domesticity than as scientists or in other professional situations. Domestic themes such as childcare could still be seen in images of female scientists or women at work.

Keywords: gender; textbook analysis; elementary school

Introduction

Female engagement in STEM (Science, Technology, Engineering and Maths) higher education and employment in Japan is exceedingly low (OECD, 2022). Girls appear to turn away from science during their middle school years, and by this time children seem to associate science with boys and men (Inada, 2021). This content analysis of the 24 textbooks authorised by MEXT (the Japanese Ministry of Education) for use in the Japanese elementary school science classroom examines how images found in these books frame female gender roles. First, Tendo's (2000) concepts of gender categorization and gender framing are described and applied to science education and science textbooks in Japan. Then there is a description of the method, with reference to

Loan's (2010) framework for carrying out a gender-focused content analysis. Finally, the results are presented and discussed in relation to Arnot's (2002) three patterns of transmission to demonstrate how the images in Japanese elementary school science textbooks frame science and employment in STEM as masculine, thereby reproducing and reinforcing hegemonic gender codes around science and employment.

Takayama (2011) describes two problematic discourses that often affect studies of Japanese education. The first is the 'discourse of particularity,' that ignores Japanese diversity and describes Japanese education in terms of Japanese exceptionalism. The second is the 'discourse of universality,' which portrays an essentialized Japan that can be used as a testing ground for Anglo-American theories and frameworks, rather than as a site where theory can be created or developed. To avoid these pitfalls, in this study, Japanese language research is recognised as valuable for its theoretical insights rather than merely as a source of raw data by drawing on Tendo's (2000) use of gender codes to describe a mechanism for maintaining and reproducing male hegemony. The Japanese context is compared and contrasted with other contexts around the world to highlight both similarities and differences to other educational contexts. Furthermore, to recognise some of the diversities of experiences within the Japanese elementary science classroom, the analysed textbooks are compared to each other, and the differences are highlighted.

Literature Review

The socio-sexual division of labour and the gender code

The socio-sexual division of labour is integral to the social structure of capitalist systems as the separation of family from the production process requires some family members to leave the home to work while some stay home to carry out domestic duties

(Arnot, 2002). In Japan, a post-war conservative political consensus established a society based on a gender ideology that expected women to stay at home and men to work (Kuwahara, 2001). Steps towards a more equal society have met with a conservative backlash (Miyazaki, 2018; Yamaguchi, 2017). As a result, Japan was placed at 116 on the Global Gender Gap Report 2022 (WEF, 2022); Japanese women earn less than their male counterparts; are more likely to be in precarious, casual, or part-time work; and are less likely to be represented at senior levels of a company or business in comparison to women in other MEDCs (Gender Equality Bureau, 2019). These issues are particularly noticeable in STEM. While Japanese women make up around 45% of the total workforce (National Statistics Centre, 2022), only 16.6% of researchers in STEM fields are women (Gender Equality Bureau, 2020) and only 16.7% of female students entering tertiary education in 2019 majored in STEM subjects (OECD, 2022). Such figures suggest that some barriers are specific to STEM fields (Ogawa, 2022).

The socio-sexual division of labour is maintained and reproduced by the gender code (Arnot, 2002). Codes regulate relationships between and within contexts (Bernstein, 2003). Gender codes are a form of regulation that combine the elements of 'gender categorization' and 'gender framing' to legitimize, sustain and reproduce gender differences, where gender categorization is connected to the power to define genders, and gender framing to the control of social interactions that makes gender hierarchies seem natural (Tendo, 2000). In schools, gender categorization can be seen in the mandating of different uniforms for boys and girls. Gender framing occurs through communication, between teachers and students as well as students and students (Tendo, 2021). Categorization alone is not enough for the reproduction or maintenance of hegemony and so it is gender framing that allows for the composition and re-

composition of the dominant culture as concepts of gender are internalized by children and come to be seen as 'natural'. The transmission and reproduction of gender codes therefore maintains male hegemony through a form of internal consent (Tendo, 2000).

Gender categorization and school science classes

After family and pre-school experiences, compulsory schooling becomes the place where codes are transmitted and the reproduction of the socio-sexual division of labour occurs and hegemony maintained (Arnot, 2002). By the time Japanese students reach junior high school, many have already categorized science as a male domain (Sumida et al. 2001). While elementary school students report enjoying science classes, there is a turn away from science among junior high students that shows a gendered pattern (Harada et al., 2018). Despite this, implicit association tests among junior high school girls show a positive attitude towards science that conflicts with their self-reported attitude (Uchida & Mori, 2012).

The belief that 'brilliance' is required for sciences, especially the 'hard' sciences of physics and chemistry, and that this brilliance is a male trait, has been observed around the world in countries such as the USA (Starr, 2018), Kenya (Kitetu, 2008), and Switzerland (Deiglmayr et al., 2009). That these beliefs about gender and science correlate with performance in school science exams has been shown in implicit association tests across multiple countries, including Japan (Nosek et al., 2009), as has the correlation between gender stereotypes and female representation in the STEM workforce (Miller et al., 2015). In Japan, 'brilliance' is associated with subjects requiring strong math skills and logical thinking such as physics, mathematics, and mechanical engineering (Ikkatai et al., 2021). Among junior high school students there is a perception that boys are better than girls at science and maths (Libertas Consulting, 2018). Self-efficacy, or the perception of one's own abilities, is a major mediator for

behaviour, and is affected strongly by gender stereotypes; female university students in Japan report lower self-efficacy in fields that are seen as requiring 'brilliance' (Adachi, 2014). In contrast, STEM fields that are considered to require social abilities, such as those related to medicine, are seen as the most suitable for women (Ikkatai et al., 2020).

Gender framing and science textbooks

Gender is framed through multiple sites, behaviours and means of communication. One such site is the curriculum. In many school contexts, curricula are communicated through published textbooks. This formal curriculum as selected, organized and validated by dominant classes or class segments is not neutral but is 'the result of complex power relations and struggles among identifiable class, race, gender and religious groups' (Apple, 2013, p. 170). However, this struggle is not clearly visible in classroom texts. Instead, textbooks are used as a means of control to legitimize existing social relations by implying that there are no alternatives to the viewpoint in the text (Sleeter & Grant, 1991). This is especially the case in science textbooks where the very nature of science is often presented as an objective search for measurable truth (Bazzul & Sykes, 2011; Hausbeck & Phillips, 2000). Textbooks are not divorced from context, so as well as repressing argument, this presentation of science connects to other discourses and transmissions of the gender code that define binary masculine and feminine ways of knowing the world, confirming science as a male domain (Namatende-Sakwa, 2019).

In Japan, science textbooks are written by private publishers according to the course of study provided by MEXT, and then submitted to MEXT to be authorized for classroom use. Textbooks for state schools are selected from this list of approved books by local education boards and distributed to the schools under their remit. Teachers at

elementary level are forbidden to supplement or replace these texts with other published material, though they are allowed to use self-produced supplementary material, and it is mandatory for teachers to use the set texts for at least a portion of class time (MEXT, n.d.). These textbooks, therefore, are the physical expression of knowledge as selected, legitimized, and imposed by the state.

As 'implicit or explicit messages communicated through a range of semiotic particulars and social options' (Cook-Gumperz, 2009, p. 295), gender codes are framed and transmitted to learners through both words and images in textbooks. Images are an important part of the gender framing process as they carry information that is not necessarily present in the written mode (Kress & van Leeuwen, 2005). The sentence, 'The speaker sat in the chair,' gives no information about the appearance of the speaker or chair, whereas an image must show at least some of this information. In written Japanese, where pronouns are rarely used, an image can carry information about gender that a sentence cannot. On the other hand, images can also lack information contained in a sentence. There is no way for an image alone to show denotive meaning, and so images have an ideological dimension as they may give an inaccurate impression of fair representation (Machin, 2013). An image of a scientist in a textbook can be seen as representative of all scientists, thereby transmitting codes related to what scientists do and who can do science.

Arnot (2002) describes three patterns of transmission - invisibility, depictions of low status, and an emphasis on domesticity – that pass on the gender codes surrounding science. The language and images in textbooks give children access to choices about who they may become (Deckman et al., 2018), but invisibility or poor representation of women in science textbooks is common around the world. Content analysis of science textbooks in, for example, Turkey (Kahveci, 2010), Jamaica (Lodge & Reiss, 2021;

Whiteley, 1996), the U.K. and Ireland (Murray et al., 2022), Syria and Romania (Blumberg, 2009), Brunei (Elgar, 2004), and the U.S.A. (Pienta & Smith, 2012) have shown that images and mentions of men, and especially male scientists, outweigh those of women and female scientists. In Japan, comparative analysis of textbooks from five publishers from 1985 and 2015 showed that while the numbers of visible women had increased, photographs and illustrations of adult men still made up 70% of the images of adults across textbooks (Inada, 2018). Science textbooks are a place where students find role models, both of people involved in 'everyday' science, and of people who are recognised for their achievements in the field. Images of few or no women as involved in science confirms that science is not a place for women to work. The erasure of women from the history of science means that the work of women is hidden and removes potential 'cultural touchstones' or inspirations for women to progress in scientific careers (Murray et al., 2022) while also confirming the masculine nature of 'brilliance'.

'Brilliance' can be seen in sections of textbooks highlighting the achievements and discoveries of famous scientists. These 'people to study' (Sleeter & Grant, 1991) are presented as notable and worthy of learning about, and therefore accord the scientist a high status. Analysis of textbooks in the U.K. and Ireland shows a strong bias towards mentions of men in both text and images in such sections (Murray et al., 2022). Status can also be demonstrated through the activity of the participants or through the visual grammar of the image (Kress & van Leeuwen, 2005). Visual analysis of images in Jamaican science textbooks showed that men were given greater salience than women, according to Jamaican norms regarding posture and eye contact (Lodge & Reiss, 2021).

Often, while men are shown in work, women are shown at home. This phenomenon of female domesticity has been seen in science textbooks in, for example,

Jamaica (Whiteley, 1996), Indonesia (Gumilar et al., 2022), and the U.K. and Ireland (Murray et al., 2022). Gender is often socially constructed as binarised (Francis et al., 2016), and as such the theme of domesticity can extend beyond the location shown in the image to any context that can be conceived as one half of an oppositional pair. Thus, in the context of science, domestic images may therefore include themes of nature (through, for example, fertility and childbirth) that are held in opposition to the abstract mechanical world of men. While patterns of invisibility and low stature diminish women's involvement in science and valorise men's, the pattern of domesticity amplifies female involvement in domestic labour and sets it against a male world of paid work.

The aim of this study was to investigate how images in science textbooks frame women's roles regarding STEM. Drawing on the three patterns of transmission described by Arnot (2002), one main research question and three sub-research questions were devised.

Main research question:

How are adult women framed in the images found in Japanese elementary school science textbooks?

Sub-research questions:

1. How visible are women and female scientists in the images in Japanese elementary school science textbooks?
2. What level of status is afforded to women in the images in Japanese elementary school science textbooks?

3. What activities are adults portrayed as engaged in in images in Japanese elementary school science textbooks?

Method

Content analyses of textbook images focus on what can be seen in images, classifying them according to specified dimensions or variables such as participants or activities (van Leeuwen & Jewitt, 2004).

Sample

The sample for the study consisted of the images of adults across six series of four books authorized by MEXT for use in elementary science classrooms for the 2022 academic year. Table 1 lists the textbook series and the number of school boards that adopted each series.

The 24 textbooks were scanned and each image containing adult participants was recorded. In total, 1655 images featuring participants identifiable as adults were found. Images in which the gender of the participants could not be established were discarded from the study. This occurred due to the style (in the case of illustrations or diagrams), size of image or participant, obstructions such as scenery or hazmat suits, or when only a small part of the body was visible. In total, 1451 images were included in the analysis.

Instruments

The use of tally sheets to count the number of men and women has been common in this form of analysis over several decades, (e.g. Deckman et al, 2018; Kahveci, 2010; Sleeter & Grant, 1991; Whiteley, 1996). Decisions about gender were made according

to characteristics such as beards or breasts, body and face shape, hair styles, clothing, and where possible, name. For gender to be established, more than one of these criteria needed to be filled. Though the use of physical characteristics to determine gender betrays a concept of gender as based in sex differences, there is no attempt here to essentialize gender into a binary or naturalistic distinction, rather to recognise the dominant notions of the culture in which the textbooks are located (Hausbeck & Phillips, 2000). As the codebook for this project was developed inductively, there was space to add transgender or non-binary identities, however without individuals explicitly identified as such, these identities were masked (Deckman et al., 2018).

Following Ceglie & Olivares (2012), individuals shown in images (the 'participants') were coded as scientists if they were engaged in a scientific procedure, pictured with scientific paraphernalia, dressed in laboratory gear and/or described in the immediate surrounding text as a scientist. Teachers engaged in teaching science lessons were coded as scientists, while other teachers were not. As a measure of status, the surrounding text was also checked to see if the person or people in the image were named, and the names recorded.

Participants in images were coded according to an adapted version of the framework provided by Loan (2010). After an initial evaluation of the images, three of Loan's original categories were removed and three new categories were added. Some of the remaining categories were renamed to better reflect the focus of the study on adults engaged in science. From these categories, sub-categories were created inductively, based on the content of the images themselves. Codes were determined by the activity and the objects visible in the image, as well as any surrounding text that described the image content. Codes were not exclusive, with many participants receiving two codes.

Data analysis

To measure visibility, the numbers of men and women were recorded. In some cases, composite images contained the same person several times or the same participant could be found in different images from the same textbook, so both the instances and the actual number of participants were noted. The instances and actual number of scientists were recorded in the same manner.

Two measures were used to determine status. The course of study for elementary school science covers two themes: Matter and Energy, and Life and Earth (MEXT, 2018). As 'brilliance' is commonly associated with the computational and logical sciences of physics and chemistry, visibility in the Matter and Energy sections was taken as a proxy for association with 'brilliance' and high-status science. As a second measure of status, names were used as a measure of whether a scientist was presented as a 'person to study'. Generally, named scientists were separated from the main body of the text either in boxes or framed pages. Sometimes these sections were woven into relevant parts of the textbook, and sometimes they were in the supplementary material or on the inner front and back covers.

Domesticity was measured through an analysis of the codes drawn from Loan (2010). After coding the participants, comparisons were made between codes applied to images of men and codes applied to images of women. The final list of categories can be seen in Table 2.

To establish the dependability of the gender and scientist codes (Schwandt et al., 2007), a second coder coded a randomly selected 10% of the images (N=146), that included images from all six series of books (van Leeuwen & Jewitt, 2004). Cohen's Kappa was calculated for the categories 'instances of males' (95.2% agreement, κ=.911), 'instances of females' (93.9% agreement, κ=.874), 'instances of male

scientists' (89.8% agreement, κ=.771), and 'instances of female scientists' (98% agreement, κ=.846).

Results and Discussion

This presentation and discussion of the results of the content analysis is structured around Arnot's (2002) three patterns of transmission and the three sub-research questions.

Visibility

The first sub-research question concerned the visibility of women and female scientists. In all series there were fewer images featuring women than featuring men, fewer instances of female participants, and fewer female individual participants. Furthermore, in every series not only were there more male scientists than female scientists, but female scientists made up a smaller proportion of scientists than women made up of the total instances or individuals.

The most balanced portrayals were in the series Wakuwaku Rika, where 50% of the coded images featured women (54.5% featured men, images featuring both accounting for the overlap), and in Atarashī Rika where 44.4% of instances of adults were women. The greatest imbalances were in Tanoshī Rika (Shinshū Kyōiku) as only 26.9% of images featured women, and in Mirai wo Hiraku as only 28.3% of the instances of adults were women, figures in line with those reported by Inada (2018).

In terms of scientists, Wakuwaku Rika was again the most balanced. However, this was mainly caused by the presence of both male and female scientist mascots – recurring characters that guided readers through the books. When these repeated instances are removed from the calculation, the figures show a greater imbalance. The

largest gap was in Tanoshī Rika (Shinshū Kyōiku) where 34.5% of the individuals portrayed were women, compared to 11.1% of the scientists. Table 3 shows the numbers of instances and individual adults and scientists across all six series.

Not only were women more poorly represented, but the location of images in the book may also have contributed to their invisibility. In two series - Tanoshī Rika (Dai Nihon) and Atarashī Rika - the highest proportion of images containing women and of female participants were found in the extra materials, such as answer keys, self-study sections, and safety guides. In four series, the largest number of instances of female scientists were also found there. Actual classroom use of textbooks varies from teacher to teacher, with teachers reporting that they use the textbooks mainly as a guide for themselves, preferring to use the textbook for reviewing or as a source of diagrams and images to illustrate their own input (Takahashi & Fujiwara, 2018). In these two series, therefore, women were in sections of the textbook potentially less likely to be seen by learners.

Whether or not the men and women featured in science textbooks are engaged in science or not, the imbalance towards men frames science as a male phenomenon by presenting men as 'normal' in science textbooks (Namatende-Sakwa, 2019). Through the weight of numbers alone, both the field of science and employment in science are framed as masculine.

Status

The second sub-research question asked about the level of status afforded to women and female scientists. There were two main measures of status. The first was an association with 'brilliance' through portrayal in the Matter and Energy chapters of the textbooks. The second was whether the participants in images were named or not. Both measures demonstrated that men were afforded a higher status than women across each series.

In every series there were both more images and a higher proportion of images containing women in the Life and Earth related sections than the Matter and Energy related sections. There was also a higher number of instances of women in the images in the Life and Earth sections than in the Matter and Energy sections across all six series. The greatest difference was in Atarashī Rika, where there were 134 instances of women in Life and Earth, compared to 66 instances in Matter and Energy. However, in Wakuwaku Rika and Minna to Manabu, women made up a slightly higher proportion of the instances of adults in Matter and Energy than Life and Earth. When participants with multiple instances were controlled for, individual women also made up a greater proportion of participants featured in the Matter and Energy sections of Atarashī Rika and Mirai wo Hiraku. As for scientists, neither Tanoshī Rika (Shinshū Kyōiku) nor Atarashī Rika featured any female scientists in the Matter and Energy sections of the textbooks. In contrast, Wakuwaku Rika, Mirai wo Hiraku and Minna to Manabu featured a higher proportion of female scientists in the Matter and Energy sections than Life in Earth. When multiple instances of the same participants were accounted for, this finding still held true for Wakuwaku Rika and Mirai wo Hiraku. Numbers of adults and scientists in each section can be seen in Table 4 and Table 5.

In every textbook series, more male scientists than female scientists were named, and in four series named female scientists were also more poorly represented than female scientists as a whole. Here, the differences between Matter and Energy and Life and Earth were starker. Table 6 shows the numbers and locations of the named scientists. There were no female ‘people to study’ in the Matter and Energy section of any textbook, and the only named woman in any of the 24 textbooks was the Marie Curie mascot guiding learners through the grade 6 edition of Minna to Manabu.

The ‘people to study’ included both famous and ‘everyday’ scientists. Most of the famous scientists were described in terms of their achievements, and all apart from Marie Curie, Jane Goodall, and Rachel Carson were men. As well as famous scientists, all the series apart from Tanoshī Rika (Shinshū Kyōiku) used this page layout to forefront ‘ordinary’ scientists and non-scientists such as Paralympians, gardeners, and chefs. Among these scientists there was much less of a gender imbalance, however the numbers involved were quite small. 13 male scientists were given a voice in this way, compared to seven female scientists. It is important to show ‘real’ women at work (EPMEWSE, 2022), however, while men were shown as both ‘ordinary’ and ‘brilliant’, few women were presented as high status enough to be considered a ‘person to study’.

The low status afforded to women can also be seen in the recurring mascots that guided learners through Tanoshī Rika (Shinshū Kyōiku) and Mirai wo Hiraku. In the first, there were four adult mascots. Not only did the male mascots represent 82.5% of instances of mascots, but they were dressed as scientists while the female mascots were dressed in everyday wear. While all four characters played the role of teachers, the men were presented as more ‘science-y’ than the women, and therefore of a higher status. In Mirai wo Hiraku, there were three mascots. Two were teachers, one male and one female, and the third was Professor Ochanomizu, a male scientist character from a long running comic book series. The lower status role of teacher, available to both men and women, can be contrasted with the higher status, exclusively male, role of scientist. The gender and characterization of the mascots by series and level can be seen in Table 7.

As a further measure of status, an interesting contrast arose within the code for ‘success’. This code was used for images of awards ceremonies and statues. When compared to the code for ‘professional’, it became clear that while men were recognised for their achievements in science, women were recognised as successful athletes (Table

8). This frames science as an abstract domain of men who use their minds and pits it against the binary opposites of femininity and the body.

It was also notable that in three books there were images of Asuka Kamiya, a junior high school student who used what she learned in school science lessons to design a magnetised recycling bin that sorted cans based on the alloy they contain. Two of these books showed her receiving an award for her idea, according her a recognition of status that was not afforded to any adult women in any of the books. Content analysis by Inada (2018) of previous editions of elementary school science textbooks concluded that girls and boys had equal portrayals in the books in terms of both activity and number. The message is that science is an acceptable subject for all children to study, and for girls to succeed in at school, but that employment in science is for men and not women.

Domesticity

The third sub-research question asked what activities adults were engaged in in the textbook images. The results of the coding can be seen in Table 9. Women were underrepresented in professional activities in all series, while men were underrepresented in images connected to homemaking, pregnancy and parenting in all series except Wakuwaku Rika.

While some images were clearly connected to dominant categorizations of gender, others were more representative of some of the multiplicity of Japanese masculinities other than the ‘salaryman’ (Taga, 2005), and femininities beyond the ‘good wife, wise mother’ paradigm (Kano, 2017; Miyazaki, 2018). Some men were shown as actively engaged in parenting or carrying out domestic tasks such as preparing food in a kitchen for a family. Likewise, several women were portrayed as athletes or firefighters. However, these represented only a very small proportion of the images.

Themes of domesticity were not limited to location in the home. Even in images featuring women in professional occupations, themes related to domesticity could be seen. For example, of the eight women coded as 'medicine', six were either performing ultrasounds on pregnant women or explaining pregnancy and childbirth to children. Of the two female firefighters, one was shown in an elementary school playground teaching a child how to use a lever to lift a block. Where images of male rescue workers were used to illustrate this principle, they were engaged in real rescues. The female firefighter was shown in a care-adjacent teaching role, and the male rescue workers as exhibiting bravery in dangerous professional situations.

In combination

The three patterns of invisibility, status and domesticity have been treated separately above, but work together to frame science as masculine. For example, within the images coded 'Agriculture, Forestry, and Fishing' there were 21 individual female participants. Two (9.5%) of the women were named and described respectively as a gardener and a veterinarian. Of the 21 participants, six were engaged in fertilizing fruit trees and seven in drying harvested food (plums, fish) and flowers. Only one was shown using any equipment more complex than a brush. In contrast, there were 93 men coded as 'Agriculture, Forestry, and Fishing' and 16 (17%) were named. They were engaged in a much wider range of farming related activities, including planting, watering, and harvesting crops, catching fish, logging, and feeding animals. They were also shown using complex and large machinery such as tractors, seed drills, and chainsaws. They were shown analysing and assessing situations, such as the numbers of fish in fish farms or damage caused by volcanic eruptions. In accompanying texts, they were described as involved in the decision-making processes around farming. Several images were concerned with valorising the achievements of men such as Nakayama Kyuzou, who

designed a new irrigation system. Here we can see the weight of numbers combined with the portrayal of men as successful high-status decision makers, the connections between machinery and men, and the connection of women to domestic themes. That these images are not directly concerned with scientists matters less for the framing of science as masculine than their location in a science textbook.

A clear demonstration of this phenomenon comes from the portrayal of a female veterinarian named Maruyama in the 5th grade Minna to Manabu textbook. Maruyama was afforded many of the markers of a high-status role; she was named, and her life story was shared in a short first-person text. She was shown at work in a well-paid professional job. In the largest image she was shown in the most dynamic position and, unlike her male helper, her role was described in the accompanying caption. However, this main image is of Maruyama helping a cow calve. She was featured in a 'natural' setting and there was no machinery present. A smaller image showed Maruyama with elementary school children, taking a teaching role. Other images showed Maruyama as a child, and the accompanying text highlighted her desire to help and to heal sick animals, placing her clearly in the discourses of domesticity as a caring, feminine woman, and undermining her high-status portrayal as a scientist.

Conclusions

Tendo (2000) describes the roles that gender categorization and gender framing play in the creation of the gender code. In this study, the power to categorize lies with the Japanese national government through MEXT as well as with local governments and boards of education. MEXT not only set the criteria and approve a limited number of textbooks, but also enforce the use of these books in the classroom. These textbooks have the authority to frame the gender roles of women in relation to science. In education systems where teachers and schools have greater freedom regarding the

materials that they use, the locus of power may be different.

Though there was wide variation between the textbook series in this study, this content analysis demonstrates all six series of textbooks frame employment in science as masculine, and thereby help to reproduce a gender code that maintains male hegemony and the socio-sexual division of labour. Not only are female scientists made invisible through omission, but far fewer women of any profession are portrayed in the images. Combining the concept of 'brilliance' with Sleeter and Grant's (1991) description of 'people to study,' alongside an analysis of activity drawn from Loan (2010), has shown that men are more likely to be associated with the concept of 'brilliance' and are more likely to be portrayed as successful or as worthy of study. Themes of domesticity, such as childcare, pregnancy, and food preparation are more likely to seen in images of women. Conversely, women are less likely to be seen in professional roles or as having responsibilities outside the home. Furthermore, men are more likely to be shown as engaged in 'mind' work while women are celebrated for their bodies, and men are more likely to be associated with machinery, while women are associated with nature.

This framing potentially discourages both girls and boys from seeing science as a suitable pursuit for adult women, making the hegemonic gender code seem natural, and allowing for its reproduction across generations. While a change in the editorial policies of textbooks will likely do little to change the issues that female scientists face when joining the work force, a more equitable balance in the number and selection of images, one that ensures a wider range of femininities are represented, may encourage both girls and boys to see potential futures for women in science.

Limitations

There are three main limitations of this study. The first is that content analysis, while able to show quantities of specific variables, cannot be used to show significance or interpreted meaning (van Leeuwen & Jewitt, 2004). How a given student interprets the images they are exposed to is influenced by a wide range of factors not investigated here. Secondly, the location of an image within a unit and the unit within the textbook will impact how many learners actually see it. There are a variety of reasons why elementary school teachers may decide to use certain parts of the textbook or not (Takahashi & Fujiwara, 2018), and so students using the same book in different classes may be exposed to different images. A gender-focused study on the varied and diverse uses of and responses to the textbook in the classroom would be illuminating. Finally, teachers are likely to use a variety of self-produced materials, or other authorised support materials such as workbooks or worksheets. Including these materials in this analysis would have provided a fuller picture of the experiences of Japanese elementary students.

Ethics statement

This study involved no human or animal participants and so no ethics approval was required.

Disclosure Statement

The author reports there are no competing interests to declare.

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