



# The gender representation of women and men in the occupational areas of STEM and care work in German textbooks

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## ARTICLE INFO

### Keywords:

STEM  
Care work  
Gender roles  
Textbooks  
Quantitative text analysis

## ABSTRACT

Science, technology, engineering, and mathematics (STEM) occupations and care work occupations are highly segregated by gender. School textbooks play an essential socializing role in determining which occupations are perceived as typically male or female. Existing research on the gender representation of STEM and care work occupations in textbooks is limited in scope. Therefore, we used quantitative text analyses in a large sample of 202 current German textbooks to examine the gender representation of STEM and care work occupations. We used collocation analysis to explore the nature of the occupational representations, focusing on agency and communion. Men were portrayed significantly more frequently than women in STEM and care work occupations. Adjectives of agency and communion occurred rarely in the collocations. Further research is required to test our findings in other cultures and to take a more differentiated look into the use of agency and communion in textbooks.

## 1. Introduction

Gender stereotypes provide culture-based traditional assumptions about how women and men are or should be (Prentice & Carranza, 2002). These stereotypes have several implications. For example, they lead to men being attributed more responsibility for gainful work and to women being attributed more responsibility for the family (Eagly, 1987; Eagly & Wood, 2012). In addition, different occupations tend to be classified as more masculine or feminine (White & White, 2006). Science, technology, engineering, and mathematics (STEM) occupations are associated with men, masculinity, and agency, whereas care work<sup>1</sup> occupations are associated with women, femininity, and communion. These stereotypical assessments of occupational areas are reflected in reality (Bettio et al., 2009; Bundesagentur für Arbeit, 2021; Cortes & Pan, 2017; Froehlich et al., 2020). In Germany, for example, only around 15 % of employees in STEM are women (Bundesagentur für Arbeit, 2019b). By contrast, at about 77 %, the majority of employees in care work are women (Bundesagentur für Arbeit, 2021).

There are various reasons for the emergence of gender-role stereotypes and the associated stereotypical career choices (Blackburn et al.,

2002; Dunlap & Barth, 2019; Lent & Brown, 2002). Socialization is one crucial reason that has been extensively researched (Grusec & Hastings, 2015). In addition to various socialization agents (such as parents or peers), the media plays an essential role in conveying gender-role stereotypes (Gallagher, 2013; Prot et al., 2015). Gender representation and associated stereotypes are central elements in gender stereotyping (Eagly et al., 2000). Gender-stereotyped media representations significantly impact children at an early age (Prentice & Miller, 2006) and adolescents (Gehrau et al., 2016). Textbooks play a crucial role (Curdts-Christiansen, 2017). They are used as central teaching tools on a daily basis for many years (Stará et al., 2017) and at a stage when gender role identity is developing (Ruble et al., 2006). They thus have an essential and sustainable influence on gender stereotypes as well as gender-stereotypical career aspirations and choices (Abele, 2014).

The analysis of gender representations in textbooks has a long tradition (Chisholm, 2018; Moser, 2016; Mustapha & Mills, 2015; Ott, 2021). While numerous studies address the portrayal of men and women in different settings (Moser, 2016; Ott, 2021), relatively few studies focus on gender portrayals in different occupations. The few existing studies do not differentiate between occupational areas but focus on

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<sup>1</sup> Care work describes the area of (un)paid activities that involve various forms of support, development, and recovery of people and includes both classic care work occupations such as nursing as well as teaching (Brückner, 2010). In a similar way, this occupational area is also recognized and discussed in research under the term HEED (Croft et al., 2015; Watt, 2008, 2010).

women and men being portrayed in typically male or female activities or occupations (Finsterwald & Ziegler, 2007; Lindner & Lukesch, 1994; Ott, 2017b), or they only examine the portrayal of women and men in STEM occupations (Kerkhoven et al., 2016). This means that there is a lack of textbook analyses contrasting the gendered representation of STEM occupations on the one hand and care work occupations on the other. Furthermore, existing studies mainly focus on frequency differences between women and men are portrayed in various occupations but neglect the nature of the portrayal (Lee, 2014; Ott, 2015). Finally, so far, textbook analyses have mainly used content-analysis approaches (Ott, 2017a), resulting in fairly small-sized corpora. Although quantitative methods have become more common in recent years (Carrol & Kowitz, 1994; Lee, 2014; Sell & Farreras, 2017), there is still a lack of studies that use methods like quantitative text analysis for larger textbook corpora, for investigating the representation of men and women in both STEM and care work, as well as the nature of their representation.

For these reasons, the present study examines on (a) the gender representation of STEM occupations and care work occupations in current German textbooks,<sup>2</sup> and on (b) how men and women are portrayed in these occupations. To answer our research questions, we analyzed a large number of textbooks with the help of quantitative text analysis.

## 2. Women and men in the occupational areas of STEM and care work

The term STEM encompasses various occupations requiring extensive technical, mathematical, or scientific knowledge or skills (Bundesagentur für Arbeit, 2019a). Most positions in the STEM area are held by men, and, generally, the STEM area is strongly associated with maleness (Stewart-Williams & Halsey, 2021). The term *care work* refers to the area of (un)paid work that involves various forms of support, development, and recovery of people (Brückner, 2010). Care work includes classic occupations like *nurse* and less classic occupations such as *teacher* or *educator* (Aulenbacher et al., 2018). Employees are mainly women, and care work is considered a highly female-connoted occupation area (England, 2005; ILO, 2018).

The gender segregation of both occupational areas can be illustrated well in the German labor market (Hausmann & Kleinert, 2014). The latest report by the German Federal Employment Agency (Bundesagentur für Arbeit, 2019b) distinguishes between three STEM sectors: (a) mathematics and natural sciences, (b) computer science, and (c) technology. Across all three STEM sectors, with a total of 7.9 million employees, the percentage of women was 15.4 %. Of 0.38 million employees in total in mathematics and natural science occupations, 37.5 % were women. In the computer science sector, with a total of 0.8 million employees, it was 16.3 %. In the technology sector, with a total of 6.7 million employees, the percentage of women was 14.1 %. In addition to lower participation rates of women in STEM occupations, two other characteristics are evident: First, women are significantly more likely than men to be employed part-time (28.1 % and 4.9 % respectively) in STEM occupations in Germany (Bundesagentur für Arbeit, 2019b). Second, there are regional differences. Due to different economic structures, the parts of Germany that belonged to the former German Democratic Republic have a higher proportion of women in STEM occupations and working full-time than the remaining parts (Bundesagentur für Arbeit, 2019b; Hobler et al., 2020).

The German Federal Employment Agency (Bundesagentur für Arbeit, 2021) distinguishes between three care work sectors: (a) health and social work, (a) education and teaching, and (c) other services and private households. These are still predominantly female sectors, as the actual figures (Bundesagentur für Arbeit, 2021) show. In the health and social work sector, with a total of 4.96 million employees, the proportion

of women is 77 %. In the education and teaching sector, with a total of 1.31 million people employed, the proportion of women is 72 %. In the sector that includes occupations providing other services and private households, with a total of 1.16 million employees employed, the proportion of women is 64 %. Across all these three sectors, women are oftentimes employed part-time (Bundesagentur für Arbeit, 2021). Furthermore, care work occupations often have a lower (hierarchical) social recognition than other paid forms of employment (Klinger, 2013). It has been shown, for example, that the lower salary of primary school teachers compared to secondary school teachers is based on the gender-stereotypical devaluation of care work-related activities (Koehler et al., 2006).

### 2.1. Gender-stereotypical dimensions of the occupation areas of STEM and care work

The different proportions of women and men in certain occupations are related to gender stereotypes (Koch et al., 2015). Gender stereotypes describe gender-related social and cognitive categorization processes (Hannover & Wolter, 2019). According to the social role theory (Eagly, 1987; Eagly & Wood, 2012; Prentice & Carranza, 2002), gender stereotypes reflect certain characteristics men and women have (descriptive norms) or should have (prescriptive norms). The dimensions of agency and communion are fundamental in describing the content of gender stereotypes (Abele et al., 2016; Bakan, 1966; Diekmann & Eagly, 2000; Eagly et al., 2020; Sczesny et al., 2018; Williams & Best, 1990). These dimensions play an essential role in the perception, characterization, and judgment of self, others, and groups (Abele & Wojciszke, 2007), particularly for gender-specific occupational roles (Charles & Bradley, 2009; Eagly et al., 2020) and are usually measured using adjectives on self-report rating scales (Pietraszkiewicz et al., 2019).

Agency describes the pursuit of one's goals, personal independence, mastery, and goal attainment. It is usually measured using adjectives such as *active*, *dynamic*, *efficient*, *assertive*, *self-confident*. Agentic qualities related to achievement or prestige are often associated with male-dominated STEM occupations (Hsu et al., 2021; Korlat et al., 2023). *Communion* involves the consideration of others and social relationships, participation in the community, and striving for the common good. It is usually measured in adjectives such as *helpful*, *understanding*, *reliable*, *likable*, *empathetic*, *friendly*. Communal qualities such as empathy and caring are often associated with female-dominated care-work occupations and roles (Froehlich et al., 2020; Levanon & Grusky, 2016; Lippa et al., 2014).

### 2.2. The influence of textbooks on gender-specific understanding of STEM and care work

The adoption of gender stereotypes as part of the socialization process begins with young children at around 12 months and continues throughout the lifespan, with appropriation occurring particularly in preschool and primary-aged children (Fagot et al., 2000; Martin, 2000) and during adolescence (Koenig, 2018; Olsson & Martiny, 2018). Girls are more likely to adopt communal gender-role beliefs and identities, while boys are more likely to adopt agentic gender-role beliefs and identities (Klaczynski et al., 2020; Korlat et al., 2022, 2023; Su et al., 2009). This contributes to gendered educational and career choices and pathways (Eccles, 2009, 2011), with girls favoring female-dominated career fields and boys favoring male-dominated career fields (OECD, 2017; Wicht et al., 2022).

In addition to family, friends, and school, the media are considered an essential instance of socialization (Genner & Süß, 2017). Textbooks are relevant here. As central teaching, learning, and working tools for school instruction, they are used daily (Gräsel, 2010; Stará et al., 2017) and therefore constitute an integral part of the knowledge transfer of social norms and values (Höhne, 2003; Weitzman et al., 1972). Textbooks often guide how teachers organize and design their lessons and

<sup>2</sup> These are textbooks for German language classes. The term *German textbooks* was used in the study for better readability.

explicitly and implicitly convey specific social ideas and beliefs about social categories such as gender, race, and ethnicity (Apple, 2013). They specify the social or occupational roles as well as the behavioral patterns each gender is associated with (Höhne, 2005). Studies have shown the influence of textbooks on the development of gender stereotypes in children (Curdt-Christiansen, 2017; Flex et al., 1976; Karniol & Gal-Disegni, 2009; Trepanier-Street & Romatowski, 1999; Witt, 2001). In a literature review, Moser (2016) summarized that children who worked with gender-fair representations developed more flexible and less traditional ideas about careers than children exposed to stereotypical representations. Good et al. (2010) showed that girls understood chemistry tasks better when they included non-stereotypical representations, for instance female scientists. How job titles are presented in textbooks also plays a central role in conveying gender stereotypes. For example, it has been shown that children and students perceive occupations as masculine if they are not described in a gender-fair way (Fisk, 1985; Liben et al., 2002). Primary school children perceived occupations stereotyped as masculine as suitable for both sexes if mentioned in gender-fair language (Verweken & Hannover, 2015; Verweken et al., 2013).

### 2.3. Gender representation in previous textbook studies

The analysis of gender representation in textbooks has a long tradition in international textbook research and has seen various developments since the 1960s (Chisholm, 2018; Mills & Mustapha, 2015), which are also applicable to the German-speaking region (Fichera, 1996; Hunze, 2003; Moser, 2016; Ott, 2021). The following overview of the feminist textbook research is structured into three periods (1960–1980, 1990–2000, 2000–present), shifting focus from general gender representation to occupational role representations. Due to the similar development of the results of German and English feminist textbook research, both language areas are summarized together.

Early feminist textbook research,<sup>3</sup> mainly focused on frequency differences in the portrayal of women and men. Later studies saw an increase in theoretical and methodological complexity as evidenced by the adoption of psychologically and linguistically informed approaches within the framework of feminist theory. Most of those studies looked into of gendered occupational representations but did not systematically classify them as typically female or male.

From the 1960s to the 1980s, in the spirit of the second women's movement, early feminist textbook analyses aimed to investigate the general invisibility of women and their stereotypical representations (Fichera, 1996) and were closely linked to ideological critique (Apple, 1978; Bernstein, 1975). Textbook studies targeted school textbooks (Elbracht & Mosler, 1972; Marten & Matlin, 1976; Ohlms, 1984; Sol-lwedel, 1968) as well as higher-education materials (Bourque & Gros-sholtz, 1974; Ehrlich, 1971; Slocum, 1975) and children's books (Lobban, 1975; Weitzman et al., 1972). In a content analysis of 18 picture books for preschool children, Weitzman et al. (1972) found 261 pictures of men and 23 pictures of women in all the books. This was a ratio of 11:1, and none of the books showed women in an occupational role. Using content analysis, Marten and Matlin (1976) examined 16 elementary school reading books. They found that only 23 % of the main characters were female and 30 % of the pictures were of women. Similarly, Karsten (1976) detected in a content analysis of 11 reading books a high skewedness towards men (71 % to 29 % for male versus female), and whereas 70 % of references to males were illustrated, only 30 % of references to females were illustrated. References to occupations were 87 % male and 13 % female, with 89 % stereotypically male

occupations (e.g., technical and production occupations) and 11 % female occupations (e.g., service and support occupations).

In the early 1990s, the focus of textbook analyses shifted to the question of whether earlier criticism led to any improvements with regard to gender representations (Clark et al., 2005; Crabb & Bielawski, 1994; Fichera, 1996; Preinsberger & Weisskircher, 1997; Witt, 1997). Only marginal improvements were found (Moser, 2016; Mustapha & Mills, 2015). In a content analysis of six high-school-level history textbook, Clark and Mahoney (2004) found that references to women increased by about 11 percentage points - from 5 % to 16 % - between the 1960s and the 1990s. In their content analysis of 46 preschool children's books published in 1940–1996, Davis and McDaniel (1999) found that the proportion of texts about women increased slightly from 35 % between 1940 and 1971 to 39 % between 1972 and 1996. At the picture level, the proportion remained the same at 37 %. Lindner and Lukesch (1994) used content analysis to analyze texts and pictures in 72 German textbooks published between 1971 and 1992 covering the subjects of German, mathematics, basic sciences, and religion in primary and secondary education. The authors found 32 % female representation out of 9471 individuals at the text level, but only 13 % of women were represented in occupational roles. Of 2225 occupational roles, 35 % represented typically female occupations (including social-care occupations) with a female share of 62 %, and 36 % generally represented male occupations (including doctors and academic occupations) with a female share of 12 %. At the picture level, with a total of 6992 individuals, the proportion of females portrayed was 39 %, and out of a total of 797 coded occupational roles, the proportion of women was 16 %.

Since the 2000s, feminist textbook research has shown that changes in stereotypical gender representations in textbooks have been very slow (Anderson & Hamilton, 2005; Denny, 2011; Evans & Kimberly, 2000; Finsterwald & Ziegler, 2007; Kerkhoven et al., 2016; Lee, 2014; Ott, 2017b). Lee and Collins (2009) used content analysis to analyze texts and images in ten Australian English textbooks. At the text level, out of 3330 individuals, the proportion of representations of men amounted to 58 %. In the illustrations, out of 489 pictures, the imbalance was even more drastic with male representations amounting to 81 %. Furthermore, more men (68 mentions) than women (38 mentions) appeared in occupational roles at the picture level. Kerkhoven et al. (2016) used visual content analysis to examine 327 online science education resources at the primary school level, including astronomy, biology, chemistry, geology, mathematics, physics, and technology. Of 3191 individuals, 33.7 % were boys, 29.9 % were girls, 22.7 % were men, and 13.7 % were women. One focus of the study was the gender representation of STEM occupations and teachers. Teachers were defined as non-STEM occupations regardless of their subject area. They found that more men (75 %) than women (25 %) were represented in STEM occupations, and more women (63.9 %) than men (36.1 %) were represented as teachers. Lee (2014) used quantitative text analysis techniques (Carrol & Kowitz, 1994) to examine three English as a foreign language (EFL) textbooks for Japanese learners. A collocation analysis of the adjectives used to describe men and women showed that women were often described with adjectives relating to their age and appearance (*x years old, old, young, little*) and emotional states (*afraid, annoyed, irritated*). In contrast, men were more often described with adjectives relating to their physical appearance and mental strength (*tall, big, heavy, strong, and brave*) and to their success and wealth (*important, rich, and poor*). Finsterwald and Ziegler (2007) used content analysis to analyze illustrations in 28 primary school textbooks from 1996 to 2001. The proportion of women in the illustrations (40 %) and women in occupational roles (26 %) was lower than that of men. When portrayed in occupational roles, men were more likely to be portrayed as craftsmen, farmers, and workers, while women were more likely to be portrayed as housewives and teachers. Interestingly, men were portrayed more often than women in typically female occupations (41 %), and women were portrayed less often than men in typically male

<sup>3</sup> Textbook studies have evinced methodological shortcomings (Bock, 2018; Fritzsche, 1992; Knecht et al., 2014; Marienfeld, 1976). A lack of consistent methods, samples, and results make them hard to compare. This is especially the case for feminist textbook research (Ott, 2017a).



occupations (7 %). Moser and Hannover (2014) subjected nine German and nine mathematics textbooks to content analysis. They found more male characters (53.5 %) than female characters (46.5 %) in the German books. Furthermore, there were significantly more men (34 mentions; *factory manager, gardener, roofer*) than women (19 mentions; *teacher, journalist, veterinarian*) in occupational roles. The range of occupations was wider for men (25 different occupations) than for women (13 different occupational roles). Regarding mathematics books, more men (11.2 %) than women (8.2 %) and more boys (33.7 %) than girls (28.3 %) were depicted. Men appeared more often in occupational roles (25 mentions) than women (12 mentions), and the range of occupations was wider for men (with 16 occupations such as *doctor, salesperson, teacher, and blacksmith*) than for women (with nine different occupations such as *salesperson, therapist, and teacher*).

Ott (2017b) conducted one of the most comprehensive studies, using a discourse-linguistic multilevel analysis of 88 German-language textbooks (56 from the subject of mathematics and 32 language textbooks) published in the German Empire (1871–1918), the Weimar Republic (1919–1933), Nazi Germany (1933–1945), and the Federal Republic of Germany (1949–2014). Across all periods, women were represented less frequently in general mentions (33.68 %) and occupational mentions (16.4 %). Ott (2017b) identified three developments: References to children (e.g., *kinderlos* [childless], *kinderlieb* [fond of children]), socially desirable characteristics (e.g., *lieb* [kind], *gut* [nice], *gutmütig* [good-natured]), and positive emotions (e.g., *freudestrahlend* [beaming with joy], *freudig* [joyful]) mainly were ascribed to women, whereas attributes concerning physical and intellectual performance (e.g., *erstklassig* [first-class], *außerordentlich begabt* [exceptionally gifted], *eifrig* [eager], *erfahren* [experienced]), healthy/unhealthy (e.g., *verwundet* [wounded], *schwach* [weak], *stark* [strong]) and negative emotions (e.g., *unzufrieden* [dissatisfied], *erschüttert* [shaken], *besorgt* [worried]) mainly were ascribed to men.

It goes without saying that any text analysis of textbooks in German has to pay attention to the peculiarities of the German language, for instance the use of gender-specific occupational titles and the generic masculine. These features impact the gender-specific perception of occupational roles (Stahlberg et al., 2007; Verweken et al., 2015; Verweken & Hannover, 2015, 2013). For this reason, a few German-language textbook analyses have also been concerned with gendered language since the 1980s. For example, Moser and Hannover (2014) examined in their content-analytic study of recent mathematics and German textbooks and found that most occupational titles were masculine. With regard to general personal nouns, non-gendered forms (e.g., *Kind* [child], *Leute* [people]) were used in most cases (57 % in German textbooks and 76.5 % in mathematics textbooks), followed by masculine generics (e.g., *Schüler* [male pupil], *Partner* [male partner]) at 31.3 % for German textbooks and 18.4 % for mathematics textbooks and feminine-masculine word pairs (e.g., *Schülerinnen* [female pupils] und *Schüler* [and male pupils]) at 11.6 % for German textbooks and 5.2 % for mathematics textbooks.

In summary, there have been some improvements in the representation of gender in textbooks (in both German and English) since the beginning of feminist textbook criticism in the 1960s. Even though the visibility of women has increased, and portrayals of women and men have become less stereotypical gender stereotypes persist to this day. Women are portrayed less often in occupations than men, and when women are portrayed in occupations, they are primarily shown in care work occupations and described with stereotypically feminine adjectives.

Although existing research provides some important insights into the portrayals of men and women in textbooks and how have changed over time, several research gaps remain. First, the analysis of occupational roles to date has been unspecific and narrow in focus, examining occupational representations along broad categories such as ‘typically female/male’ or ‘women’s and men’s occupations’ or focusing only on STEM occupations. In addition, the dimensions of agency and

communion have been understudied despite their potential to bring to the fore the gender stereotypes underlying the portrayal of occupations in textbook. Second, most analyses have been conducted with small samples and used different forms of content analysis. While this approach permits an in-depth analysis of textbooks, it is only possible to examine small numbers of textbooks manually, which makes the results less representative. In recent years, computer-based quantitative text analysis has become a useful option that has been successfully applied in other research areas (Madera et al., 2009; Tausczik & Pennebaker, 2010) but also in a couple of textbook studies (Carrol & Kowitz, 1994; Lee, 2014; Lee & Chin, 2019; Lee & Collins, 2015). However, these studies lack a systematic consideration of occupational representation and neglect the dimension of agency and communion.

#### 2.4. Aims of the present study

For these reasons, in our study, we used quantitative text analysis methods to examine the gendered representation in STEM and care work occupations in a large text corpus of 202 German textbooks that are currently approved and used in the state of Bavaria. Our first aim was to analyze the extent to which men and women are portrayed in STEM and care work occupations. Our second aim was to find out whether different attribute dimensions of agency and communion are used to describe women and men in these occupational representations. Based on existing research (Lippa et al., 2014) and the actual career choices and participation of women and men in these occupations (Eccles, 1994; Sinclair & Carlsson, 2013; Weisgram et al., 2010), we expected men to be more often represented in STEM occupations and less frequently in care work occupations. Furthermore, we expected more agency-related adjectives for men in STEM occupations and more communion-related adjectives for women in care work (Froehlich et al., 2020; Korlat et al., 2023).

### 3. Method

#### 3.1. Sample

The complete digital textbook corpus consisted of more than 1000 German, Mathematics, English, and Science textbooks, which were created in the project *Gender & Care in the Media* of the Bavarian research association ForGenderCare. For our study, we made a sub-corpus of 202 German textbooks from primary and secondary schools (grades 1 to 13). All textbooks were selected according to the following criteria: (1) they were approved as learning resources by the Bavarian State Ministry of Education and Cultural Affairs as learning resources in Bavarian schools between 2001 and 2018 and are still in use, and (2) they are subject to the resolution on fair gender representation in textbooks in Germany (Beschluss zur Darstellung von Mann und Frau in Schulbüchern, 1986). Table 1 provides an overview of the characteristics of our textbook sample. All textbooks in the corpus were digitized using the OCR software Abby Fine Reader 11 and converted into a text file using the UTF-8 encoding scheme. A script was used to convert possible gender-fair abbreviations of occupational terms (e.g., *Lehrer/-in* [female

**Table 1**  
Characteristics of the German textbook sample.

Characteristic	<i>n</i>
Number of textbooks	202
Number of pages	47,842
School types	
Primary school	57
Secondary school	145
Grades	
1–4	57
5–9	135
10–13	10

and male teachers]) into feminine-masculine word pairs (e.g., *Lehrerin und Lehrer* [female and male teachers]).

### 3.2. Data collection

For both aims, we developed word lists of terms for STEM and care work occupations. The selection of occupational terms was based on the official occupational classification of the German Federal Employment Agency (Bundesagentur, 2011). To account for grammatical gender in German, we devised two lists of occupational terms: one for females and one for males.

The word list of STEM occupation terms contained 286 male terms (e.g., *Physiker* [male physicist], *Chemiker* [male chemist]) and 286 female terms (e.g., *Physikerin* [female physicist], *Chemikerin* [female chemist]).

The word list of care work occupation terms contained 523 male terms (e.g., *Lehrer* [male teacher], *Arzt* [male doctor]) and 535 female terms (e.g., *Lehrerin* [female teacher], *Ärztin* [female doctor]).

To achieve Aim 1, we used the text analysis program LIWC (Pennebaker et al., 2015), which analyzes text files and calculates the percentage of words from a particular dictionary file. The program contains a dictionary with 74 possible linguistic categories, such as emotions or social processes. It consists of 2300 words and word stems and its validity has been confirmed in several studies (Pennebaker & King, 1999; Tausczik & Pennebaker, 2010). In our study, LIWC compares the word lists of STEM and care work occupation terms with the text corpus of digitalized textbooks and counts their frequency.

To achieve Aim 2, we used the corpus linguistics program AntConc 4.2 (Anthony, 2022) to analyze the collocations of the adjectives referring to the terms of STEM and care work occupations. Collocations reveal a specific semantic coloring and/or discourse meaning of one (or more) word(s). The words to be studied are referred to as nodes, and the words that co-occur with these nodes are called collocates (Pollach, 2012). The word lists of STEM and care work occupations were specified as nodes, and the range of collocates was set to five words on either side of the node word (Carroll & Kowitz, 1994). To measure the evidence for a positive association between the nodes and the collocates of the words, a log-likelihood (LL) of  $p < .05$  with a threshold of 3.48 or higher was included in the analysis. The mutual information (MI3) score (Brezina et al., 2015) was calculated to measure the strength between the nodes and the collocates. According to Hunston (2002), the MI score indicates “how strongly two words seem to associate in a corpus, based on the independent relative frequency of the two words” (p. 72). An MI3 score of three or more is considered significant (Carroll & Kowitz, 1994; Hunston, 2002; Lee, 2014).

### 3.3. Data analysis

To analyze the data for Aim 1, the results from LIWC were exported to the statistical program SPSS 25 and prepared for further analysis. Since the data did not follow a normal distribution, a Wilcoxon Sign Rank Test was used to test the significance of the terms counted from the word lists. A chi-squared test of independence was used to test whether men were more likely to be shown in STEM occupations and less likely to be shown in care work occupations.

To analyze the data for Aim 2, the results were exported to an Excel file. All adjectives that co-occurred with the node words (male and female forms of STEM and care work occupational terms) and had an MI3 score of three or higher and a log-likelihood (LL) of  $p < .05$  with a threshold of 3.48 or higher were highlighted, resulting in 614 adjectives. Following previous work on larger text corpora (Caldas-Coulthard & Moon, 2010; Hunston, 2002; Pollach, 2012), we selected the 20 adjectives with the highest MI3 scores. The adjectives were then reduced to their basic grammatical form (e.g., *genialsten* to *genial* [most ingenious to ingenious]), and any duplicates were removed. The final step was the explorative-qualitative interpretation (Hunston, 2002; Pollach, 2012). We assessed the 20 adjectives and, where possible, assigned them to the

attribute dimensions of agency and communion. The content mapping was based on the previous descriptions of agency and communion (Abele & Wojciszke, 2007; Pietraszkiewicz et al., 2019; Szczesny et al., 2018). All remaining adjectives were grouped into other attribute dimensions based on their content meaning.

## 4. Results

### 4.1. Representation of women and men in the occupational areas of STEM and care work

Our first aim was to investigate whether men are more likely to be represented in STEM occupations and less likely to be represented in care work occupations (Aim 1). We first examined whether men were more often represented in occupational areas to get a general picture. Overall, men ( $n = 6248$ , 74.58 %,  $M = 20.93$ ,  $SD = 25.24$ ) were represented significantly more often ( $Z = 11.32$ ,  $p < .01$ ) than women ( $n = 2130$ , 25.42 %,  $M = 10.54$ ,  $SD = 11.63$ ) in occupational areas. Regarding differences between the occupational areas, our analyses showed that care work occupations ( $n = 7699$ , 91.90 %,  $M = 38.11$ ,  $SD = 29.49$ ) were mentioned significantly more often ( $Z = 12.26$ ,  $p < .01$ ) than STEM occupations ( $n = 679$ , 8.10 %,  $M = 3.40$ ,  $SD = 6.47$ ). Turning to the gender distribution in the two occupational areas now, our expectations were not met as men were more often represented in both occupational areas ( $\chi^2(1, N = 8378) = 47.07$ ,  $p < .01$ ). In STEM occupations, men ( $n = 581$ , 85.57 %,  $M = 2.88$ ,  $SD = 5.54$ ) were significantly more often represented ( $Z = 8.36$ ,  $p < .01$ ) than women ( $n = 98$ , 14.43 %,  $M = 0.49$ ,  $SD = 2.06$ ). In the occupational area of care work men ( $n = 5667$ , 73.61 %,  $M = 28.05$ ,  $SD = 22.24$ ) were also significantly more often represented ( $Z = 11.24$ ,  $p < .01$ ) than women ( $n = 2032$ , 26.39 %,  $M = 10.06$ ,  $SD = 10.12$ ). Finally, we identified the top three occupations represented by women and men in STEM and care work occupations. In the occupational area of care work men were most frequently mentioned as *Lehrer* [male teacher] ( $n = 2274$ , 40.85 %,  $M = 11.26$ ,  $SD = 10.36$ ), *Arzt* [male doctor] ( $n = 581$ , 10.44 %,  $M = 2.88$ ,  $SD = 5.07$ ), and *Professor* [male professor] ( $n = 337$ , 6.05 %,  $M = 1.67$ ,  $SD = 4.52$ ) whereas women were most frequently mentioned as *Lehrerin* [female teacher] ( $n = 1034$ , 50.89 %,  $M = 5.12$ ,  $SD = 5.63$ ), *Ärztin* [female doctor] ( $n = 45$ , 2.21 %,  $M = 0.22$ ,  $SD = 1.90$ ), and *Schulleiterin* [female school principal] ( $n = 22$ , 1.08 %,  $M = 0.11$ ,  $SD = 0.75$ ). In STEM occupations, men were most frequently mentioned as *Physiker* [male physicist] ( $n = 139$ , 23.92 %,  $M = 0.69$ ,  $SD = 4.11$ ), *Ingenieur* [male engineer] ( $n = 21$ , 3.61 %,  $M = 0.10$ ,  $SD = 0.863$ ), and *Techniker* [male technician] ( $n = 10$ , 1.72 %,  $M = 0.05$ ,  $SD = 4.11$ ), whereas women were most frequently mentioned as *Schornsteinfegerin* [female chimney sweep] ( $n = 9$ , 9.18 %,  $M = 0.04$ ,  $SD = 0.55$ ), *Physikerin* [female physicist] ( $n = 8$ , 8.16 %,  $M = 0.04$ ,  $SD = 0.58$ ), and *Technikerin* [female technician] ( $n = 6$ , 6.12 %,  $M = 0.03$ ,  $SD = 0.31$ ).

### 4.2. Characteristics of women and men represented in the occupational areas of STEM and care work

We then conducted a collocation analysis to examine the distributional differences of adjectives from the agency and communion dimensions when used to describe men and women in the occupational areas of STEM and care work (Aim 2). All collocations with a Mutual Information (MI3) score of 3 or higher and a Log-Likelihood (LL) of  $p < .05$  with a threshold of 3.48 or higher were included in the analysis. Table 2 shows the 20 adjectives with the highest MI3 scores. Where possible, adjectives were assigned to the agency and communion dimensions, and all others were grouped into other attribute dimensions based on their content meaning. This resulted in *positive*, *negative*, *occupation-specific*, and *other attribute dimensions*. Table 3 shows the results for STEM occupations and table 4 for care work occupations.

For the male terms of the STEM occupations, there was only one adjective (*genial* [ingenious]) showing an association with the agency

**Table 2**  
Top 20 adjectives from the collocation of male and female STEM and care work occupations.

male		n	Log Likelihood	MI3	female		n	Log Likelihood	MI3
German	English				German	English			
maßgeschneidert	customized	5	68,271	15,841	zoologisch	zoological	35	52.843	17.202
geisteskrank	insane	4	52,724	14,875	technisch	technical	5	56.894	14.284
besoldet	salaried	3	39,542	14,045	chemisch	chemical	3	38.307	13.810
eigeweiht	privy	4	43,014	13,174	mathematisch	mathematical	2	28.336	13.640
agil	agile	2	26,361	12,875	biochemisch	biochemical	1	16.747	13.448
ausgestopft	stuffed	2	26,361	12,875	astronomisch	astronomical	1	15.308	12.448
querschnittsgelähmt	paraplegic	2	26,361	12,875	bakteriell	bacterial	1	15.308	12.448
genial	ingenious	3	30,999	12,045	begabt	gifted	3	32.620	12.448
umsichtig	prudent	2	23,485	11,875	organisiert	organized	1	15.308	12.448
vernetzt	connected	2	23,485	11,875	botanisch	botanical	1	14.480	11.863
niederländisch	Dutch	2	21,831	11,29	geologisch	geological	1	14.480	11.863
mathematisch	mathematical	2	21,206	11,068	statistisch	statistical	2	22.897	11.693
astronomisch	astronomical	1	13,18	10,875	programmiert	programmed	2	22.475	11.541
blendend	blinding	1	13,18	10,875	geografisch	geographical	1	13.078	10.863
komischgrotesk	comically grotesque	1	13,18	10,875	physikalisch	physically	1	12.498	10.448
kurzsichtig	short-sighted	1	13,18	10,875	amerikanisch	American	3	24.291	10.441
physikalisch	physical	2	20,666	10,875	analytisch	analytical	1	11.684	9.863
störungsfrei	interference-free	1	13,18	10,875	physisch	physical	1	11.523	9.747
technisch	technical	4	29,505	10,746	biologisch	biological	1	10.470	8.988
chemisch	chemical	3	25,278	10,676	systematisch	systematic	1	7.9970	7.200
Care work									
besserwisserisch	know-it-all	5	45.542	12.557	weltlich	secular	10	75.465	13.502
berufstypisch	professionally	5	45.542	12.557	priesterlich	priestly	2	24.411	12.091
streng	strict	18	53.752	11.802	schmerzlindernd	pain-relieving	2	24.411	12.091
ausgebildet	trained	7	46.141	11.766	medizinisch	medicinal	5	41.599	12.057
schwindsüchtig	consumptive	4	34.548	11.592	mutig	brave	7	46.166	11.785
tätig	active	15	46.913	11.387	chirurgisch	surgical	3	28.945	11.524
skeptisch	skeptical	8	38.313	10.837	ärztlich	medical	3	27.824	11.261
feige	cowardly	3	25.911	10.762	tätig	active	10	43.153	11.132
obergescheit	know-it-all	3	25.911	10.762	bedauernd	regretfully	2	21.42	11.091
schwindelfrei	free from giddiness	5	31.954	10.65	diakonisch	diaconal	2	21.42	11.091
angepasst	adapted	10	36.707	10.638	orthopädisch	orthopedic	2	21.42	11.091
verwitwet	widowed	2	20.259	10.592	pharmazeutisch	pharmaceutical	2	21.42	11.091
deutsch	German	18	24.315	10.413	professoral	professorial	2	21.42	11.091
plastisch	plastic	3	24.116	10.346	verehrungswürdig	worshipful	2	21.42	11.091
katholisch	catholic	5	28.603	10.165	fachgerecht	professional	3	26.066	10.846
angemessen	appropriate	11	29.482	10.137	unglaublich	untrustworthy	2	19.731	10.506
anwesend	present	8	30.805	10.132	gemeinsam	together	18	22.716	10.329
lehrhaft	didactic	4	26.261	10.132	französisch	French	5	27.199	9.969
geboren	born	22	11.762	10.119	gelernt	learned	4	22.113	9.391
feige	cowardly	9	30.445	10.113	physikalisch	physical	3	19.975	9.387

Note. n = frequency of the adjectives that occur five words to the left and five words to the right of the occupation term; MI3 = cubed variant of the mutual information statistic.

dimension and no adjectives showing an association with the communion dimension. In the collocations of the female terms of the STEM occupations, there was only one adjective (*begabt* [gifted]) showing an association with the agency dimension and no adjective that showed an association with the communion dimension.

For the male terms of the care work occupations, only one adjective (*tätig* [active]) could be assigned to the agency dimension, and no adjective was associated with the communion dimension. For the female terms of the care work occupations, two adjectives (*mutig* [brave], *tätig* [active]) were associated with the agency dimension and one adjective (*gemeinsam* [together]) was associated with the communion dimension.

It should be noted that most adjectives could neither be classified as communion-related nor as agency-related. We further investigated these adjectives by categorizing them into three semantic dimensions: positive, negative, and occupational-specific; adjectives that could not be assigned to any of these categories were classified as “other” (see Tables 3 and 4).

For men in STEM occupations, we grouped five adjectives as occupation-specific (e.g., *mathematisch* [mathematic], *astronomisch* [astronomical]), three as positive (e.g., *genial* [ingenious], *umsichtig* [prudent]) and one as negative (*geisteskrank* [insane]). 11 adjectives belonged to other attribute dimensions. In the female terms of STEM occupations, we categorized 13 adjectives as occupation-specific (e.g.,

*zoologisch* [zoological], *technisch* [technical], *chemisch* [chemical]), one as positive [*begabt* [gifted], and six as other.

With five adjectives, quite a lot of collocations of the male terms of care work occupations were negative (e.g., *besserwisserisch* [know-it-all], *streng* [strict], *feige* [cowardly]), four were positive (*ausgebildet* [trained], *angepasst* [adapted], *angemessen* [appropriate] and *lehrhaft* [didactic]) and one was occupation-specific (*berufstypisch* [professionally]). Nine adjectives were classified as other. In the collocations of women’s terms for care work occupations, seven adjectives were categorized as occupation-specific (e.g., *medizinisch* [medicinal], *ärztlich* [medical], *pharmazeutisch* [pharmaceutical]), five adjectives were positive (e.g., *mutig* [brave], *verehrungswürdig* [worshipful]). Two adjectives were categorized as negative (*bedauernd* [regretfully] and *unglaublich* [untrustworthy]). Four adjectives were categorized as other, including the two adjectives with the highest association (*weltlich* [secular] and *priesterlich* [priestly]).

## 5. Discussion

The first aim of our study was to investigate the gender representation of men and women in the occupational areas of STEM and care work in a large sample of German textbooks. Based on the gender segregation in the occupational areas of STEM and care work (Aulenbacher et al.,

**Table 3**  
Attribute dimensions of the top 20 adjectives from the collocations of male and female STEM occupations.

agency		communion		positive		negative		occupation-specific		other attribute dimensions	
German	English	German	English	German	English	German	English	German	English	German	English
STEM male											
genial	ingenious			genial	ingenious	geisteskrank	insane	mathematisch	mathematical	maßgeschneidert	customized
				agil	agile			astronomisch	astronomical	besoldet	salaried
				umsichtig	prudent			physikalisch	physical	eingeweiht	privy
								technisch	technical	ausgestopft	stuffed
								chemisch	chemical	querschnittsgelähmt	paraplegic
										vernetzt	connected
										niederländisch	Dutch
										blended	blinding
										komischgrotesk	comically grotesque
										kurzsichtig	short-sighted
										störungsfrei	interference-free
STEM female											
begabt	gifted			begabt	gifted			zoologisch	zoological	bakteriell	bacterial
								technisch	technical	organisiert	organized
								chemisch	chemical	programmiert	programmed
								mathematisch	mathematical	amerikanisch	American
								biochemisch	biochemical	physisch	physical
								astronomisch	biochemical	systematisch	systematic
								botanisch	astronomical		
								geologisch	geological		
								statistisch	statistical		
								geografisch	geographical		
								physikalisch	physically		
								analytisch	analytical		
								biologisch	biological		

Note. Other attribute dimensions include adjectives from other or unclear attribute dimensions. Some adjectives could be assigned to two attribute dimensions.

2018; Blackburn et al., 2002; Stewart-Williams & Halsey, 2021) and prevailing gender stereotypes (Hannover & Wolter, 2019), we assumed that men would be overrepresented in STEM occupations and underrepresented in care work occupations. Our results only partially support our assumptions. In 202 German textbooks, men are significantly overrepresented, and women are underrepresented in both STEM and care work occupations.

The result of such a clear male dominance in STEM occupations is consistent with previous textbook studies (Kerkhoven et al., 2016; Pillion & Bergin, 2022) and general STEM research (Stewart-Williams & Halsey, 2021). However, only Kerkhoven et al. (2016) conducted a study with similar categorizations of STEM occupations. Other studies (Bühlmann, 2009; Markom & Weinhäupl, 2007; Moser & Hannover, 2014) used non-specific occupational classifications such as ‘technical occupations’ or ‘typically male occupations.’

Especially interesting is the finding that in care work occupations, men were also far more portrayed than women, with teacher, doctor, and professor being the most frequent care work occupations (as opposed to teacher, doctor, and school principal for women). This seems surprising, as occupations in this area are generally considered feminine and are primarily practiced by women (Aulenbacher et al., 2018). Furthermore, other researchers have also found a consistent female overrepresentation in care work (Ott, 2021). However, these researchers did not use a systematic occupational classification. For example, Finsterwald and Ziegler (2007) described the occupational area as ‘female connotated’ and Lindner and Lukesch (1994) as ‘women’s occupations’ without specifying which occupations were included.

To sum up, the predominantly male representation in occupational roles in textbooks is consistent with findings of previous research (Fichera, 1996; Mustapha & Mills, 2015; Ott, 2021). However, while previous researchers (Finsterwald & Ziegler, 2007; Lindner & Lukesch, 1994; Markom & Weinhäupl, 2007) used unsystematic occupational categories such as the categories ‘typically female’ or ‘typically male,’ the present study has used a systematic classification of both STEM and care work occupations (Bundesagentur, 2011) for the first time. Our

findings highlight that, in current German textbooks, gainful employment, in the form of STEM and care work occupations, is still primarily understood as a male social role. Surprisingly, such a gender-stereotypical understanding of gainful employment is still prevalent in current textbooks, especially in light of the resolution on fair gender representation in textbooks in Germany (Beschluss zur Darstellung von Mann und Frau in Schulbüchern, 1986) the discourses on social transformation processes, such as the critical discussion on the structural change of male gainful employment (Meuser, 2012; Volz, 2012) or the criticism from feminist textbook research (Chisholm, 2018).

The second aim of our study was to find out how women and men are portrayed in the occupational areas of STEM and care work. To our surprise, adjectives from the agency and communion dimensions were used rarely. While the frequency of representation of men and women in STEM occupations once more illustrates STEM is viewed as a typically male domain, our results regarding the characterization of men and women are less unambiguous. We found a somewhat unclear and mixed use of adjectives, with a tendency towards occupation-specific adjectives followed by a mix of positive, negative, and agency-referential adjectives for men in STEM occupations. Women in STEM occupations were most often associated with occupation-specific adjectives. Empirical studies with participants indicated the central role of agency and communion in career choices and decisions in STEM-related occupational areas (Abad & Pruden, 2013; Boucher et al., 2017; Froehlich et al., 2020). These studies highlight the necessity of agentic qualities (Heilman, 2012). Recent studies (Eagly et al., 2020; Korlat et al., 2023) also indicate that, for women in male-dominated occupations like STEM, communion (as well as competence and prestige) seems to play a more critical role than agency. Contrary to prior assumptions, our study indicates that textbooks use few agency and communion adjectives to describe STEM and care work occupations. Agency and communion may be constructed in other ways in the text, for example, through transitivity in grammar. Nevertheless, our results show that mainly occupation-specific adjectives are used to describe STEM and care work



**Table 4**  
Attribute dimensions of the top 20 adjectives from the collocations of male and female care work occupations.

	agency		communion		positive		negative		occupation-specific		other attribute dimensions	
	German	English	German	English	German	English	German	English	German	English	German	English
tätig	active		ausgebildet angepasst angemessen lehrhaft	trained adapted appropriate didactic	besserwisserisch streng feige obergescheit wirkungslos	know-it-all strict cowardly know-it-all ineffective	berufstypisch	professionally	schwindstichtig skeptisch schwindelfrei verwitwet deutsch Plastisch katholisch anwesend geboren	consumptive skeptical free from giddiness widowed German plastic catholic present born		
mutig tätig	brave active		mutig verehrwürdig fachgerecht gelernt schmerzlindernd	brave worshipful professional learned pain-relieving	Care work female bedauernd unglaubwürdig	regretfully untrustworthy	medizinisch chirurgisch ärztlich orthopädisch pharmazeutisch professorial physikalisch	medically surgical medical orthopedic pharmaceutical professorial physically	weltlich priesterlich diakonisch französisch	secular priestly diaconal French		

Note. Other attribute dimensions include adjectives from other or unclear attribute dimensions. Some adjectives could be assigned to two attribute dimensions.

occupations, with a slightly higher rate for women than for men. Very few adjectives refer to agency or communion for care work occupations. However, we found associations with negative and positive adjectives in the portrayal of men and, occupation-specific and positive adjectives in the portrayal of women in care work occupations. The association of negative attributes with male portrayal in textbooks in general is already known from previous research (Evans & Kimberly, 2000; Wharton, 2005). However, our study provides the first evidence of such an association related to male care work roles. The association of women with occupation-specific adjectives (e.g., *medizinisch* [medicinal], *ärztlich* [medical]) in care work occupations, by contrast, is surprising in the sense that indicates that more gender-neutral adjectives are used to describe women in care work occupations than men. To our knowledge, there are comparable results in previous studies.

Our findings suggest a new and old understanding of the occupation area of care work. It seems that current textbooks break with the gender-stereotypical understanding of care work as a female occupation with somewhat atypical gender stereotypical associations of characteristics beyond agency and communion. That said, our findings also suggest that care work is associated with men and masculinity when it comes to gainful employment.

### 5.1. Limitations and future directions

There are several limitations to the present study. First, although the digital textbook corpus was carefully scanned and manually checked to eliminate possible errors; it cannot be ruled out that incorrect text passages may still be found in the corpus. This is owed to the complex design of the textbook pages, which posed substantial problems to the scanning program. As a result, the automatic matching of digitally transformed texts with the LIWC dictionaries may have missed some words. However, other studies have shown that results with LIWC remain relatively stable with a standard level of error (Wolf et al., 2008).

Second, our study does not analyze gender(un)fair language. The use or non-use of gender-fair language has a significant impact on the construction of gender roles (Sczesny et al., 2016) and occupational perceptions (Vervecken et al., 2015; Vervecken & Hannover, 2015, 2013), and is therefore an integral part of textbook-related research (Kiesendahl & Ott, 2015). As we changed gender-fair occupational titles to female-male word pairs, we could not analyze possible subtle and indirect mechanisms in the social construction of gendered occupational representations like the use of the generic masculine. Further research, for instance, content analysis on a smaller sample of the textbook corpus, is needed to fill this gap (Moser & Hannover, 2014).

The last limitation concerns theoretical and methodological issues. Our study has made initial steps to investigate whether STEM and care work occupations are described with agency and communion adjectives. However, we only used an exploratory collocation analysis to do so. Although we found little evidence of using these attribute dimensions in our study, further research should explore the issue in more detail and with other methods (Bock, 2018; Klerides, 2010). For instance, a qualitative approach such as language and grammar analysis (Kiesendahl & Ott, 2015) could be used to get a better idea of how women and men are described in our sample of textbooks and whether these descriptions relate to agency and communion, e.g., examining the grammar of transitivity to gender and agency (Nuttall, 2019; Simpson et al., 2019; Pietraszkiewicz & Formanowicz, 2023). The current findings could also be extended by examining the representation of STEM and care work occupations related to other categories, such as socioeconomic status and ethnicity (Duffy, 2005; Ferree & Hall, 1996; Puentes & Gougherty, 2013) or by investigating how unpaid care work is represented in terms of gender, to learn more about the social separation of private and gainful employment (Davies & Frink, 2014).



## 6. Conclusion

Our study found an overrepresentation of men in STEM and care work occupations in 202 currently approved German textbooks. The gender-stereotypical understanding that gainful employment is a male domain Aulenbacher, (2018) still prevails in German textbooks. These findings are particularly problematic because textbooks are used in schools daily and for many years, and thus constitute an essential socialization factor that not only influences what is considered typically masculine and feminine but also has an impact on career choices and other behaviors (Abad & Pruden, 2013; Verveckeen et al., 2015). From a practical perspective, it is necessary to put even more emphasis on gender-fair and gender-neutral representation of occupations in textbooks. This issue should be paramount in future discourse, especially since the 1986 resolution (Beschluss zur Darstellung von Mann und Frau in Schulbüchern, 1986) on the portrayal of men and women has been given too little consideration in the creation of textbook so far.

## Declaration of generative ai and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used DEEPL to improve readability and language. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the publication's content.

## Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## CRediT authorship contribution statement

**Bernhard Fruehwirth:** Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft. **Michael Heilemann:** Methodology, Data curation, Writing – review & editing. **Heidrun Stoeger:** Supervision, Writing – review & editing.

## Declaration of competing interest

None.

## Data availability

The authors do not have permission to share data.

## Acknowledgments

We thank Daniel Patrick Balestrini and Diana Wengler for their insightful comments and Franziska Streicher for her help in data gathering.

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