

**Occupational Gender Segregation in German School Textbooks:
Horizontal Segregation, Vertical Hierarchies, and Temporal
Change across HEED and STEM Domains**

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For Inge

*Who was there when I was lost, showed me what I am capable of, and introduced me to the
wonders of science.*

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Abstract

Despite decades of progress toward gender equality, occupational gender segregation remains a defining feature of contemporary labor markets, characterized by a persistent divide between healthcare, early education, and domestic work (HEED) and science, technology, engineering, and mathematics (STEM). Educational materials serve as critical socialization agents during childhood and adolescence, implicitly transmitting and preserving gender-stereotypical beliefs about the occupational world. Therefore, this cumulative dissertation examines how German school textbooks construct and reproduce occupational gender segregation along the three dimensions of horizontal segregation, vertical segregation, and temporal change. The first two studies investigate horizontal segregation and temporal change using large-scale computational text analyses. Study I reveals pervasive male dominance across both STEM and HEED domains in contemporary German language arts textbooks, challenging the assumption that female characters are overrepresented in care roles. Study II extends this longitudinally across 820 German language arts and mathematics textbooks from 1960 to 2017, demonstrating that whereas female representation in HEED increased, female STEM representation in mathematics textbooks remained statistically low, revealing significant subject-specific resistance to a 1986 governmental gender equity mandate. The third study shifts focus to the vertical dimension within vocational orientation textbooks, documenting severe hierarchical segregation. Female characters face a “sticky floor” effect in female-dominated fields, i.e., HEED-related occupations, and are entirely excluded from entry-level positions in male-dominated fields, i.e., STEM-related occupations. After a theoretical introduction and the presentation of the three studies, the general discussion synthesizes these findings along these three dimensions, concluding that textbooks continue to construct paid work as a predominantly male domain. It argues that achieving gender-equitable representation requires more than numerical parity, that horizontal and vertical distributions must be addressed separately, and that subject-specific policy guidance is needed because progress in one subject does not automatically transfer to others. The discussion acknowledges the methodological limitations of the present research and identifies as the most consequential open question whether exposure to these textbook representations affects students’ occupational aspirations.

Keywords: occupational gender segregation, HEED, STEM, textbook analysis, gender stereotypes, socialization

Zusammenfassung

Trotz jahrzehntelanger Fortschritte in Richtung Geschlechtergleichstellung bleibt die geschlechtsspezifische berufliche Segregation ein prägendes Merkmal moderner Arbeitsmärkte, gekennzeichnet durch eine hartnäckige Kluft zwischen den Bereichen Gesundheit, (frühe) Erziehung und Hauswirtschaft (HEED) sowie den Naturwissenschaften, Technik, Ingenieurwesen und Mathematik (MINT/STEM). Bildungsmaterialien fungieren in der Kindheit und Adoleszenz als entscheidende Sozialisationsinstanzen, die implizit geschlechterstereotype Überzeugungen über die Berufswelt vermitteln und aufrechterhalten. Daher untersucht diese kumulative Dissertation, wie deutsche Schulbücher die berufliche Geschlechtersegregation entlang der drei Dimensionen horizontaler Segregation, vertikaler Segregation und zeitlicher Veränderung konstruieren und aufrechterhalten. Die ersten beiden Studien analysieren die horizontale Segregation und den zeitlichen Wandel mittels computergestützter Textanalysen. Studie I zeigt eine allgegenwärtige männliche Dominanz sowohl im STEM- als auch im HEED-Bereich in aktuellen Deutschlehrbüchern auf, was die bisherige Annahme in Frage stellt, dass weibliche Charaktere in Pflege- und Sorgeberufen überrepräsentiert seien. Studie II erweitert diese Perspektive längsschnittlich anhand von 820 Deutsch- und Mathematikbüchern aus den Jahren 1960 bis 2017 und demonstriert, dass die Repräsentation von Frauen im HEED-Bereich zwar zunahm, die weibliche STEM-Repräsentation in Mathematikbüchern jedoch statisch auf sehr niedrigem Niveau verblieb. Dies offenbart eine signifikante, fachspezifische Resistenz gegenüber dem KMK-Beschluss von 1986 zur Gleichstellung der Geschlechter in Schulbüchern. Die dritte Studie verlagert den Fokus auf die vertikale Dimension innerhalb von Schulbüchern zur Berufsorientierung und dokumentiert eine gravierende hierarchische Segregation. Weibliche Charaktere sind in frauendominierten Berufsfeldern, d. h. HEED-bezogenen Berufen, mit einem „Sticky Floor“-Effekt konfrontiert und in männerdominierten Bereichen, d. h. STEM-bezogenen Berufen, vollständig von Einstiegspositionen ausgeschlossen. Die allgemeine Diskussion führt diese Ergebnisse entlang dieser drei Dimensionen zusammen und kommt zu dem Schluss, dass Schulbücher Erwerbsarbeit weiterhin als vorwiegend männliche Domäne konstruieren. Sie argumentiert, dass numerische Parität allein nicht ausreicht, dass horizontale und vertikale Verteilungen gesondert adressiert werden müssen und dass fachspezifische bildungspolitische Steuerung notwendig ist. Sie benennt die Limitationen der Untersuchung und identifiziert als wichtigste offene Forschungsfrage, ob diese Darstellungen die Berufsaspirationen von Schülerinnen und Schülern beeinflussen.

Schlüsselwörter: geschlechtsspezifische berufliche Segregation, HEED, STEM, Schulbuchanalyse, Geschlechterstereotype, Sozialisation

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Chapter 1: General Introduction

General Introduction

Occupational choices are among the most consequential decisions in an individual's life, shaping personal identity, economic well-being, and societal contribution (Christiansen, 1999; Watt, 2010; Weisgram et al., 2011) and are essential for finding meaningful work (Arendt, 1958/2020; Hardering, 2015; Laaser & Karlsson, 2022; Voß, 2010). Yet, these choices are rarely made freely. They are deeply structured by cultural expectations, social practices, and institutional arrangements, with gender acting as one of the most powerful organizing principles (Aulenbacher, 2008; Eccles, 1994; Fenstermaker & West, 2013; Schmader & Nater, 2025; Watt & Eccles, 2008). An example of this influence is occupational gender segregation, a systematic division of women and men into different spheres and hierarchical levels of work (Anker, 1997; Blackburn et al., 2002; Charles & Grusky, 2004; Jarman et al., 2012). This segregation operates along two fundamental dimensions. On the one hand, there is *horizontal segregation*, which refers to the tendency of women and men to work in different occupational fields, with women are overrepresented in female-dominated fields such as healthcare, early education, and domestic work (HEED)¹, and men predominating in male-dominated fields such as science, technology, engineering, and mathematics (STEM) (Croft et al., 2015; Fayer et al., 2017). On the other hand, *vertical segregation* refers to the overrepresentation of men in positions of authority, leadership, and advanced qualification, even in fields where the majority of the workforce is female (Blackburn et al., 2001). Together, these inequalities constrain the potential of individuals and societies, with consequences for wage equality, career mobility, and the availability of workforce in key economic and societal sectors (Bächmann, 2023; Blau et al., 2014; Kleinert et al., 2023). Understanding how this fundamental divide persists across generations is central to the present dissertation (Blau et al., 2013; Lippa et al., 2014).

¹ Throughout this dissertation, the terms “HEED” and “care work” are used in close relation to one another. The HEED framework (Croft et al., 2015) was originally conceived to cover healthcare, early education, and domestic work. It provides a systematic counterpart to STEM, facilitating direct comparison between the two extremes of occupational gender segregation. However, as a theoretical construct, HEED lacks the conceptual depth of the term *care work*, a sociological concept that encompasses a broader range of paid and unpaid labor involving the physical, emotional, and developmental support of others. This includes occupational fields such as all forms of education beyond early childhood, social work, and related service professions (Aulenbacher, 2018a; Brückner, 2010; England, 2005). For this reason, the present dissertation applies the HEED framework alongside this broader understanding of care work, extending it beyond Croft et al.'s (2015) original definition to include the entire spectrum of education-related and care-oriented occupations. Study I uses the term “care work” to reflect this broader conceptualization, whereas the theoretical chapters (and Studies II and III) use HEED to maintain consistency with the psychological literature on occupational gender segregation.

The foundations of occupational gender segregation are laid well before young people enter the labor market (Martin & Ruble, 2004, 2010; Miller et al., 2006). Gender-specific career aspirations do not emerge spontaneously in adulthood but develop through socialization processes that begin in early childhood, consolidate during the primary school years, and become particularly apparent in adolescence (Eccles, 2000; Fagot et al., 2000; Korlat et al., 2023; Olsson & Martiny, 2018; Sinclair & Carlsson, 2013). Gottfredson's (1981, 2002, 2020) theory of circumscription, compromise, and self-creation highlights that children and adolescents progressively rule out occupational options that they perceive as being inconsistent with their gender identity (Carter, 2014; Korlat et al., 2022). This process eventually leads them to narrow their choices to fields they see as accessible and appropriate. This narrowing process is influenced by multiple socialization agents, including parents, peers, and the media (Eccles et al., 1990; Ward & Grower, 2020). Of these agents, the educational materials children and adolescents encounter daily merit particular attention.

Within the educational system, state-approved curricula and textbooks convey cultural and social perceptions of which occupations are suitable for women and men (Apple, 1982; Ott, 2016; Stevenson & Baker, 1991; Wiater, 2005). As a recurring feature of daily classroom life, textbooks transcend their pedagogical function (Zala-Mezö et al., 2021). They implicitly communicate societal values and legitimize specific social roles, shaping a young person's understanding of the world of work (Apple, 1978, 1987; Arnot, 2007; Höhne, 2003; Knudsen, 2005; Stein, 1977). When textbooks depict women predominantly in care and service roles and men predominantly in technical and leadership roles, they may perpetuate the horizontal and vertical dimensions of occupational gender segregation documented in the labor market (Conway et al., 1996; Froehlich et al., 2020). Through the lens of Social Role Theory (Eagly, 1987; Eagly et al., 2000), repeatedly portraying women and men in gender-typed occupational roles normalizes a gendered division of labor, which may influence children's developing beliefs about who belongs in which occupational fields (Prentice & Carranza, 2002). Textbooks, therefore, function not merely as neutral teaching tools but as active participants in the social construction of occupational gender (Höhne, 2003; Kostas, 2023). Despite the role of textbooks as agents of occupational gender socialization, and despite a substantial body of empirical research, existing studies leave critical gaps along the three dimensions central to the present dissertation, namely horizontal segregation, vertical segregation, and temporal change.

On the horizontal dimension, although studies have consistently documented the general underrepresentation of women in occupational roles over several decades and in various national contexts (V. Lindner & Lukesch, 1994; Moser & Hannover, 2014; Ott, 2017b, 2021), few have applied theoretically grounded occupational domain classifications, such as HEED and STEM, that reflect the

actual structure of labor market segregation. Most analyses have relied on broad, ad hoc categories such as “typically female” or “typically male” occupations (Bühlmann, 2009; Finsterwald & Ziegler, 2007), without situating their findings within the bidirectional framework of horizontal segregation that characterizes contemporary labor markets (Croft et al., 2015).

On the vertical dimensions, the distribution of women and men across hierarchical levels within occupational fields, has received virtually no systematic attention in textbook research. Although Ott (2017b) analyzed qualification and hierarchy markers at the linguistic level and Finsterwald and Ziegler (2007) documented disparities in technical expertise, no study has systematically examined hierarchical positioning of characters across domains and representational modalities.

On the temporal dimension, feminist critique of educational materials in the 1970s and 1980s prompted policy responses in Germany, most notably the 1986 resolution of the Standing Conference of the Ministers of Education and Cultural Affairs (Kultusministerkonferenz [KMK]), which mandated gender-equitable representation in educational materials (Fuchs et al., 2010; KMK, 1986). Whether this mandate produced measurable changes in occupational gender representation has never been empirically tested. The few longitudinal studies that have tracked change across decades, such as those by Lindner and Lukesch (1994) and Ott (2017b), did not employ statistical designs capable of isolating the effects of a specific policy intervention, nor did they track domain-specific representation along HEED and STEM lines over time.

Beyond these dimensional gaps, a further aspect of the field has been overlooked. Specialized occupational orientation materials, which target students during the critical period when career decisions are made (Gottfredson, 2002; Haasler, 2020), have been entirely overlooked in a literature that has focused almost exclusively on general subject textbooks (Hunze, 2003; Moser, 2016; Ott, 2017a). These are the materials in which horizontal segregation and especially vertical segregation as it bears on emerging occupational aspirations can most directly be examined.

To address these gaps, the present dissertation pursues an overarching question: whether German textbooks reflect, reproduce, or contest the occupational gender segregation documented in contemporary labor markets, across three interrelated dimensions of horizontal segregation, vertical segregation, and temporal change. This dissertation comprises three complementary studies, each offering a distinct perspective. Study I provides a quantitative overview of contemporary textbooks, analyzing the representations of women and men in HEED and STEM occupations within a substantial body of German language arts textbooks. Study II adds historical depth and subject-specific comparisons by examining how these representations have evolved over nearly six decades,

investigating whether the 1986 KMK resolution mandating gender-equitable representation produced measurable effects, and exploring how temporal trends differ between gendered school subjects (i.e., mathematics and language arts). Study III conducts a detailed analysis of specialized occupational orientation textbooks, distinguishing between horizontal segregation across domains and vertical segregation across hierarchy levels in both text and images.

Together, these studies construct a comprehensive picture of how the occupational world is depicted in school textbooks in Germany. Chapter 2 establishes the theoretical and empirical framework underpinning this research. It begins by mapping the landscape of occupational gender segregation, detailing its horizontal and vertical dimensions, reviewing the theoretical perspectives most relevant to a dissertation on textbooks as socialization agents, and identifying the socialization agents through which gendered occupational knowledge is transmitted (Section 2.1). It then turns to textbooks specifically, conceptualizing them as a discourse arena, presenting the case that their representations influence students, and reviewing the empirical research on gender representation in school textbooks along the three dimensions central to this dissertation (Section 2.2). Chapter 3 presents the specific research questions following from these gaps and provides an overview of the three empirical studies. Chapter 4 synthesizes the empirical findings from across the three studies along the three dimensions. Chapter 5 closes with a general discussion of the findings, their theoretical and practical implications, the limitations of the present research, and directions for future research. The three articles on which the present Rahmenpaper is built are reproduced in full in the Appendix.

Chapter 2: Theoretical and Empirical Framework

Theoretical and Empirical Framework

2.1 The Foundations of Occupational Gender Segregation: Dimensions, Theories, and Educational Agents

This section explores the structural foundations of occupational gender segregation. This is achieved in three steps. First, it maps the landscape of segregation across its horizontal and vertical dimensions. Second, it reviews the theoretical perspectives most relevant to explaining the origins and persistence of these divisions. Third, it identifies the socialization agents through which gendered occupational knowledge is transmitted, leading to the focus on school textbooks in Section 2.2. Despite substantial progress toward gender equality in education and labor force participation, women and men still work in significantly different occupations and at different hierarchical levels (Blackburn et al., 2014; Blau et al., 2013; Kleinert et al., 2023). This persistent arrangement of occupational gender segregation is one of the most enduring features of modern labor markets (Charles & Grusky, 2004; Schouten, 2022). Sociologists distinguish between two fundamental dimensions of this phenomenon. *Horizontal segregation* refers to the division of women and men into different types of work and occupations that may have equivalent status but involve different tasks and skill requirements (Charles & Grusky, 2011; Jarman et al., 2012). *Vertical segregation*, in contrast, captures the tendency for men to occupy positions that confer greater authority, prestige, and economic rewards than those typically held by women (Blackburn et al., 2001). Although economic changes over the past century have reduced some forms of vertical inequality, horizontal segregation has proven more resistant to change and has even intensified in certain contexts (Blau, 2025; Charles & Grusky, 2004; Jarman et al., 2012).

The Horizontal Dimension: Women and Men in Different Occupational Fields

Horizontal segregation refers to sorting of women and men into different occupations under the influence of several forces, including culturally constructed beliefs about gendered abilities, the institutional and labor-market arrangements that organize work, and perceived task demands (Charles & Grusky, 2011; Wong & Charles, 2020). This allocation is remarkably consistent across national contexts. Women tend to predominate in occupations involving care, education, and interpersonal services, whereas men tend to predominate in technical and manual work (Blackburn et al., 2014; Wong & Charles, 2020). Despite some movement toward gender integration that occurred in industrialized countries during the late twentieth century, this progress has largely stalled, and the fundamental structure of horizontal segregation persists (England, 2010; England et al., 2020; Gatta & Roos, 2005).

Two broad occupational domains represent the opposite poles of the gendered spectrum. The STEM domain (science, technology, engineering, and mathematics) encompasses fields where men have historically predominated and continue to be overrepresented (Ceci & Williams, 2009; Fayer et al., 2017). In contrast, Croft et al. (2015) introduced the HEED framework (healthcare, early education, and domestic work) to highlight female-dominated fields that have received comparatively less research attention. These HEED occupations overlap substantially with what sociologists term care work or the care economy, encompassing paid labor involving the physical, emotional, and developmental support of others (Aulenbacher, 2018a; Brückner, 2010; England, 2005; Schmitt et al., 2018). Both STEM and HEED capture occupational domains that are traditionally associated with masculine and feminine roles, respectively.

The HEED/STEM distinction shows that occupational gender segregation operates in both ways. Although women are underrepresented in traditionally masculine fields, men are similarly underrepresented in traditionally feminine ones. Yet, this symmetry is often overlooked (Croft et al., 2015). England (2010), in this context, observed that women have increasingly entered male-dominated fields, whereas men have shown much less movement into female-dominated occupations. Society is more accepting of women in traditionally masculine roles than of men in traditionally feminine ones (Puzio & Valshtein, 2022). Policy efforts to encourage women into STEM fields have not been matched by similar initiatives to recruit men into care work and education (Block et al., 2019; Croft et al., 2015; Puzio & Valshtein, 2022). This asymmetry has practical consequences, since many countries now face severe shortages of care sector employees (Dowling, 2018; F. Williams, 2018).

The persistence of horizontal segregation is particularly notable in light of women's educational advances (Barone, 2011; Charles & Bradley, 2009). Globally, 112 women are now enrolled in tertiary education for every 100 men (Rubiano-Matulevich et al., 2019), and women currently make up the majority of the college-educated workforce in several industrialized nations (Fry, 2022; U.S. Bureau of Labor Statistics, 2023). However, these advances have not resulted in proportional representation across occupational fields. One possible explanation, among several, is that the growing acceptance of gender equality as a principle does not necessarily lead to a reduction in essentialist beliefs about psychological differences between women and men (Grusky & Levanon, 2014). A paradox arises in prosperous, ostensibly egalitarian societies, where individual choice is celebrated, yet the cultural and institutional forces that influence those choices remain largely unacknowledged (Charles & Bradley, 2009; Soylu Yalcinkaya & Adams, 2020).

Several mechanisms contribute to the persistence of horizontal segregation, of which the temporal organization of work is one. Jobs that offer higher pay for longer hours tend to attract a disproportionate number of men, particularly among those whose partners are primarily responsible for household management (Goldin, 2014, 2021). Conversely, occupations organized to accommodate part-time schedules and interchangeable task assignments, such as pharmacy, have achieved greater gender balance (Goldin & Katz, 2016). A second mechanism is internal differentiation: even as women have gained access to previously male-dominated professions, the growth of specializations such as family medicine, public interest law, and human resources management has coincided with women's increased representation in medicine, law, and business, creating new gender-typed niches within professions that had appeared to be integrating (Levanon & Grusky, 2016; Reskin & Roos, 1990). A third mechanism is the lower valuation of female-dominated work. Occupations in which women predominate typically offer lower wages and less prestige than those dominated by men, even after accounting for skill requirements and working conditions (Blau & Kahn, 2017; England et al., 2002; Levanon et al., 2009). Moreover, longitudinal evidence suggests that wages within occupations tend to decline as the proportion of women increases (Harris, 2022; Levanon et al., 2009). These wage penalties make female-dominated occupations less appealing to men, who face greater societal pressure to maximize their earnings as household providers (Goldin, 2014; Ridgeway, 2011).

The Vertical Dimension: Gender and Occupational Hierarchies

Vertical segregation is characterized by the overrepresentation of men in positions of authority, expertise, and leadership. This phenomenon reflects gender inequality within social hierarchies, not across occupational fields (Blackburn et al., 2001; Charles & Grusky, 2011). Even in sectors where they constitute the workforce majority, women remain underrepresented among executives, managers, and senior professionals (Eagly & Carli, 2007; C. L. Williams, 1992, 2013). Historically, the division of labor has been gendered, allocating breadwinning responsibilities primarily to men and caregiving responsibilities primarily to women, which has reinforced men's economic advantages (Bianchi et al., 2012; Gerson, 2017; Hochschild & Machung, 2012).

The advancement of women into leadership positions has been hindered by what scholars have termed the "glass ceiling," namely invisible barriers that prevent access to the highest organizational levels (Cotter et al., 2001). Conversely, the metaphor of the "sticky floor" (Berheide, 1992) captures how women, particularly in female-dominated fields, are often kept at the lowest, entry-level positions with limited opportunities for upward mobility. Synthesizing these dynamics, Eagly and Carli (2007) argue that the metaphor of a "labyrinth" more accurately captures women's

experiences, as obstacles emerge throughout their careers and not only at the top or the bottom. These obstacles include biased performance evaluations, limited access to mentorship and sponsorship, work-family conflicts exacerbated by inadequate institutional support, and persistent cultural associations between leadership and masculinity (Eagly & Carli, 2007; Heilman & Wallen, 2010). Recent reviews emphasize that the operation of these stereotypes in contemporary workplaces continues to produce measurable career disadvantages for women, even in organizations where formal commitments to gender equality have been adopted (Heilman et al., 2024). Furthermore, men's career advancement is supported by professional networks built through shared gender. In organizations where men predominate, male employees develop denser networks of same-gender contacts that provide access to information, mentorship, and opportunities (McPherson et al., 2001; Woehler et al., 2021).

Women's career progression is further hindered by their ongoing disproportionate responsibility for childcare and domestic labor, even though fathers have become more involved (Altintas & Sullivan, 2016; Ferrant et al., 2014). Cross-national time-use data from 1971 to 2010 reveal that although fathers spent more time on childcare in industrialized nations, mothers spent more time on it as well, thus preserving the gender gap (Altintas & Sullivan, 2016). More recent German data illustrate that this imbalance persists into the present. Although take-up of *Elterngeld* has become near-universal among mothers, fewer than half of fathers take any parental leave, and those who do typically take a fraction of the duration taken by mothers (Statistisches Bundesamt et al., 2024). This imbalance in unpaid care work is a key factor in women's disadvantages in the labor market (Cortés & Pan, 2020; Musick et al., 2020). Research on business leaders illustrates this dynamic. Male leaders are more likely than female leaders to have children and to have partners who work part-time or not at all, whereas female leaders are more likely to have partners who are themselves senior managers (Højgaard, 2002). Men in leadership positions are more often relieved of what Hochschild and Machung (2012) termed the "second shift" of domestic labor, enabling them to dedicate more time and energy to their careers.

These barriers are compounded by a fundamental asymmetry in the valuation of status. Work traditionally associated with men tends to be more highly valued and rewarded than comparable work traditionally associated with women (Ridgeway, 1991, 2014). This asymmetry influences the direction of gender boundary-crossing in occupations. For example, women entering male-dominated fields receive more cultural support than men entering female-dominated fields, reflecting broader tendencies whereby attributes and activities coded as masculine are valued more highly than those coded as feminine (Croft et al., 2015; Schmader et al., 2001). Progress toward

vertical equality has not been linear. Following substantial progress in earlier decades, the movement toward gender parity in leadership and high-status positions has slowed considerably and, according to some measures, has stalled or reversed (England et al., 2020; Zhu & Grusky, 2022). One influential account emphasizes that women's advancement is hindered not only by the barriers they face directly but also by the limited movement of men into caregiving roles. This perpetuates women's disproportionate domestic responsibilities (Croft et al., 2015; Hook, 2010).

Vertical segregation operates as a regime of structural and cultural barriers that hinder women's upward mobility and preserve male dominance in high-status roles. The origins and persistence of horizontal and vertical segregation have been theorized from a range of perspectives, of which the next section reviews those most directly relevant to a dissertation on textbooks as socialization agents.

Theoretical Perspectives on Occupational Gender Segregation

Multiple theoretical perspectives address occupational gender segregation, operating at different levels of analysis from individual cognition to institutional arrangements² (Anker, 1997; Bettio et al., 2009; Wong & Charles, 2020). No single framework provides a complete explanation, and segregation is understood to have multiple causes. The perspectives reviewed here are those that most directly address how socialization shapes occupational trajectories, since this is the level at which textbooks operate. Social Role Theory provides the central framework for the present work, complemented by Situated Expectancy-Value Theory on the formation of expectations and subjective values, and by Gottfredson's theory of circumscription on the developmental narrowing of occupational aspirations.

Social role theory (Eagly, 1987; Eagly & Wood, 2012; Eagly et al., 2000) proposes that the historical division of labor between women and men has produced both descriptive stereotypes (beliefs about how women and men typically behave) and prescriptive stereotypes (beliefs about

² The sociological perspective on occupational gender segregation, rooted in the gendered division of labor and the public-private dichotomy (Aulenbacher, 2018b; Bobbio, 1989; Weber, 2019), provides important structural context for understanding how historical role arrangements became institutionalized. Hausen (1976) described this process as a "polarization of gender characters," whereby deeply ingrained associations between femininity and the domestic sphere, and masculinity and the public sphere, came to influence perceptions of which occupations are appropriate for women and men (Klinger, 2012). Although a detailed discussion of this sociological perspective is beyond the scope of this review, its structural implications underpin the theoretical frameworks discussed below and are discussed in relation to the empirical findings in Chapter 5.

how they should behave). Women came to be perceived as communal (warm, nurturing, and interpersonal), whereas men came to be perceived as agentic (assertive, competitive, and achievement-oriented; Abele et al., 2008, 2016; Abele & Wojciszke, 2007). These stereotypic expectations generate beliefs about which occupations are appropriate for each gender, influence individuals' self-concepts and career aspirations, and bias employers' evaluation and selection decisions (Heilman, 2012; Koch et al., 2015). Because agency and communion are fundamental to how occupational gender stereotypes are cognitively processed and linguistically expressed (Pietraszkiewicz et al., 2019), the question of whether educational materials draw on these dimensions when describing occupational roles becomes empirically tractable. Social Role Theory thus posits a self-reinforcing cycle in which the observed concentration of women and men in different roles generates stereotypes that perpetuate future segregation, and the theory's emphasis on repeated role-based observations as the source of descriptive stereotypes makes it the framework most directly applicable to textbook representations.

A second framework central to this dissertation is *Situated Expectancy-Value Theory* (Eccles & Wigfield, 2020; Wigfield & Eccles, 2000), which addresses how individuals' developing expectations and values translate cultural messages about gender into concrete educational and career choices. The theory distinguishes two layers of influence.

Distal influences include cultural stereotypes about gender, occupational appropriateness beliefs, and the messages transmitted by parents, teachers, peers, and media. Proximal influences include the individual's developing self-concept, identity, and interpretation of past experiences. Together, these shape expectations of success in particular domains and the subjective task values (interest, attainment, utility, and cost) that guide subsequent choices (Eccles, 1987; Eccles et al., 1983). Within this framework, identity development functions as the central mediating mechanism between distal cultural messages and proximal motivational states. The work of Hannover and Kessels has been central here: students assess the fit between their emerging self-concepts and the gendered prototypes associated with subjects and occupational roles, a process they describe as self-to-prototype matching (Hannover, 2008; Hannover & Kessels, 2004; Kessels, 2005; Korlat et al., 2022). This matching helps explain why subject self-concepts become gendered well before achievement differences emerge, and why mathematics and the natural sciences, which carry strong masculine connotations, attract less identification from girls than from boys. This matching helps explain why subject self-concepts become gendered well before achievement differences emerge, and why mathematics and the natural sciences, which carry strong masculine connotations, attract

less identification from girls than from boys (Cvencek et al., 2011; Kollmayer et al., 2017; Plante et al., 2009).

A further proximal mechanism is self-efficacy, the individual's confidence in their ability to succeed in a particular domain (Bandura, 1986; Bussey & Bandura, 1999), most fully developed in Social Cognitive Career Theory (Lent et al., 1994, 2000). Gender differences in self-efficacy beliefs, particularly in mathematics and the natural sciences, persist even among students with comparable achievement (Correll, 2001; Else-Quest et al., 2010), suggesting that cultural messages about who belongs in these fields shape students' confidence independently of demonstrated competence.

A third perspective, Gottfredson's (1981, 2002, 2020) theory of circumscription and compromise, addresses the developmental narrowing of occupational aspirations. According to Gottfredson, children progressively eliminate occupations they perceive as incompatible with their emerging self-concept, beginning with judgments of gender-appropriateness between the ages of six and eight. A critical feature of the model is that once established, these gender-type boundaries prove highly resistant to revision. Occupations eliminated as gender-inappropriate during childhood rarely re-enter consideration even when later circumstances make them viable (Gottfredson, 2002; Helwig, 2001; Henderson et al., 1988). This early and enduring restriction helps explain why occupational gender segregation persists despite expanding opportunities and evolving attitudes.

What these perspectives share is an emphasis on how socialization processes feed observed segregation. Social Role Theory specifies the production of stereotypes from observed role distributions. Situated Expectancy-Value Theory describes how cultural messages and identity development shape educational and occupational choices. Gottfredson's circumscription model accounts for the developmental durability of gender boundaries on occupational possibility. The remaining question is which agents in young people's lives carry these socialization processes, and the next section addresses it.

Educational Agents and the Case for Textbooks

Occupational gender segregation has its origins in childhood and adolescence (Halim & Ruble, 2010; Martin & Ruble, 2004; Miller et al., 2006; Ruble et al., 2006). Children acquire gender categories at a remarkably early age. By two or three, most can reliably identify their own gender and categorize others accordingly (Martin & Ruble, 2004), and knowledge of occupational gender stereotypes develops rapidly during the preschool and early school years (Liben et al., 2002; Signorella et al., 1993). According to gender schema theory (Bem, 1981; Martin & Halverson, 1981; Starr & Zurbriggen, 2017), children develop cognitive frameworks that organize incoming information by gender. Once established, these schemas guide attention, memory, and inference, so that children

notice and remember information consistent with their schemas and tend to overlook or distort that which contradicts them (Frawley, 2008; Liben & Signorella, 1993). Across childhood and adolescence, gendered occupational knowledge becomes increasingly specialized and occupational aspirations become more concrete (Hartung et al., 2005).

Multiple agents contribute to the acquisition of gendered occupational knowledge throughout this period, although their relative influence shifts as children develop (Fagot et al., 2000). Parents communicate gender expectations through direct statements, differential encouragement, gender-typed toys and experiences, and modeling of occupational and domestic roles (Eccles et al., 1990; Tenenbaum & Leaper, 2003). Teachers shape students' academic self-concepts through attention, feedback, and career guidance (Carlana, 2019; Tiedemann, 2000). Peers reinforce gender norms by approving gender-typical behavior and sanctioning those who cross gender boundaries, an influence that intensifies during adolescence (B. B. Brown & Larson, 2009; Martin & Fabes, 2001). Media portrayals of occupations remain highly gender-stereotyped, with women underrepresented in professional and technical roles and overrepresented in domestic and caregiving contexts (Collins, 2011; Ward & Grower, 2020).

Among these agents, school textbooks merit particular attention for the present dissertation. Textbooks differ from the other socialization agents in their institutional sanction and their systematic, repeated deployment across the developmental periods identified above as critical, including the early years when gender schemas form, middle childhood when academic self-concepts emerge, and adolescence when occupational aspirations become concrete (Curd-Christiansen, 2017; Glock & Kleen, 2020; Leaper, 2015). They are selected, approved, and mandated by state agencies; used systematically across entire age groups, and treated as authoritative sources of knowledge by students and teachers alike (Apple & Christian-Smith, 1991; Ott, 2017b; Stein, 1991). What distinguishes textbooks from transient media exposure or informal peer interactions is precisely this combination of institutional position and cumulative, structured contact across the developmental window in which gendered occupational knowledge is acquired. Understanding how textbooks construct occupational gender requires attention to both how their content is produced and what that content contains, which is the focus of the following section.

2.2 Textbooks and the Construction of Occupational Gender

Textbooks are not neutral conveyors of information. They are selected, approved, and mandated by state agencies; used systematically across entire age groups, and treated as authoritative sources of knowledge by students and teachers alike (Apple, 1993/2014; Fuchs et al., 2014; Höhne, 2003; Stein, 1977; Stöber, 2010; Wiater, 2003). This institutional embedding means

that textbooks are active participants in the construction and reproduction of social knowledge, including knowledge about the gendered structure of the occupational world, instead of merely reflecting social attitudes. In line with Zala-Mezö et al. (2021) and building on earlier definitions (Bölsterli Bardy, 2015; Niehaus et al., 2011), this dissertation takes a broad view of textbooks as instructional materials or teaching resources comprising various components such as printed volumes, digital learning platforms, supplementary workbooks, basal readers, and picture books. As Lässig (2010, p. 203) formulated, “[...] textbooks are constructions and at the same time constructors of social orders and societal knowledge.”

This section explores the theoretical basis for viewing textbooks as spaces where occupational gender is formed and potentially conveyed to students. This is achieved in three steps. First, textbooks are conceptualized as products of discourse and social negotiation. Second, they are examined as media through which gender socialization may occur. Third, empirical research on gender representation in educational materials is reviewed and gaps in the literature are identified.

Textbooks as a Discourse Arena: Production, Control, and Knowledge Construction

The question of which knowledge is included in textbooks and how it is included has been most systematically addressed in discourse-analytic and sociological approaches to educational materials (Höhne, 2003, 2014; Keller, 2010; Lässig, 2010; Matthes et al., 2024). Research on textbooks usually distinguishes between two main functions: the societal function and the instrumental or didactic function (Gautschi, 2018; Heitzmann & Niggli, 2010; Ott, 2016; Wiater, 2003; Zala-Mezö et al., 2021). The societal function refers to the role of textbooks in defining foundational knowledge, aligning with educational policy requirements, and transmitting a society’s values and norms. The instrumental function concerns supporting teaching and learning, including the structuring of knowledge, the guiding of instruction, motivating learners, and the enabling of differentiation (Hacker, 1980; Ott, 2016; Totter et al., 2020). Although these functions are analytically distinct, they are deeply intertwined in practice, as the selection and presentation of content inevitably carry normative implications.

In his comprehensive theory of textbook knowledge, Höhne (2003) introduced the concept of the “discourse arena” to encapsulate all the discourses, institutions, and actors involved in the production of textbooks. This metaphor emphasizes both the heterogeneity of participants and the contested nature of the struggles surrounding textbook content and approval. Ott (2016) identified no fewer than 16 distinct groups of actors involved in the production of textbooks, highlighting the complexity of the negotiation processes through which their content emerges. From this perspective, textbooks are not neutral artefacts of objective knowledge, but rather the outcome of social

negotiation processes in which different societal power relations must be balanced (Höhne, 2003; Lässig, 2009). Heinze (2010, p. 125) characterized this as “a social process of selection, legitimation, and adaptation in line with educational theory.” The contents that ultimately appear in textbooks represent a form of consensus. This does not, however, simply mean compromise, but rather encompasses the powerful and hegemonic processes through which particular representations are accepted as legitimate whereas alternatives are rendered invisible (Apple, 1993/2014; Gramsci, 1948–1951/1992)

Stein (1977, 1991) distinguished three functions of textbooks: as *Informatorium* (for knowledge transmission), as *Pädagogicum* (for pedagogical purposes), and as *Politicum* (for political purposes). Although traditional textbook research has predominantly focused on the first two functions, Stein (1979) draws attention to the *Politicum* dimension, highlighting that textbooks are sites where societal conflicts are fought out and particular worldviews are legitimized. Weniger (1962) emphasized that curriculum knowledge is determined by “societal powers”, the central social actors who decide what constitutes knowledge worth teaching. Kahlert (2010, p. 42) captured the resulting significance of this by stating that textbooks “express the cultural self-understanding of a society and represent something like a core curriculum for communication in a heterogeneous society.”

The production and approval of textbooks involves multiple institutional layers that mediate the content of textbooks before they reach students (Herrmann, 2016; Höhne, 2018). In Germany, as in many other countries (Zala-Mezö et al., 2021), textbooks must undergo state approval procedures before they can be used in schools. Rohlfes (1998) characterized this process as resembling a “black box” and not a transparent procedure. It is almost invariably the state that controls the approval process (Höhne, 2018), though the specific procedures vary considerably across federal systems. In Germany, for example, some states (Hamburg, Berlin, and Schleswig-Holstein) give schools free rein, whereas others use simplified approval procedures or even commission publishers directly to develop textbooks (Ott, 2016; Stöber, 2010). Publishers, authors, subject experts, didacticists, ministry officials, and approval committees all contribute to the development of textbook content, each bringing their own particular perspectives, interests, and constraints (Höhne, 2003; Lässig, 2009; Macgilchrist, 2017a). The textbook market itself shows tendencies toward monopolization, with the number of publishers declining as smaller companies are taken over by larger ones. This development raises concerns about the diversity of available materials (Böhn & Hamann, 2016; Höhne, 2018). The result, as Höhne (2003) termed it, is a *Konstruktorium*: textbooks do not depict reality but construct specific knowledge in highly selective ways through the involvement of

numerous social actors. As Höhne (2003, p. 64) put it, “[...] in textbooks, no reality is depicted; rather, a specific knowledge is constructed in highly selective ways by numerous social actors.” The textbook is the product of a long negotiation and highly regulated control process, and its contents bear the traces of the power relations that produced them.

An important distinction concerns the relationship between textbooks and innovation versus tradition. Ott (2016) observed that textbooks appear to serve contradictory functions: some researchers characterize them as transmitters of tradition (Lässig, 2010), whereas others emphasize their role as carriers of innovation (Beerenwinkel & Totter, 2011; Fuchs & Henne, 2018; Gravemeijer, 2014; Kahlert, 2010; Totter et al., 2019). According to Ott (2016), this apparent contradiction dissolves when one recognizes that these functions apply to different knowledge domains. With regard to societal values, norms, or “common sense” knowledge, textbooks draw on knowledge that has already been negotiated and consolidated in societal discourse, functioning as transmitters of tradition. However, when it comes to didactic-methodological knowledge, textbooks may integrate the latest findings from subject-specific didactics and learning theory, functioning as carriers of innovation (Zala-Mezö et al., 2021). This distinction is particularly relevant when it comes to understanding gender representations, where the portrayal of occupational gender roles may reflect consolidated societal knowledge—including persistent stereotypes—instead of the contemporary scientific understanding of gender equality.

The relationship between curricula and textbooks is worthy of attention. In most educational systems, curricula and textbooks are closely linked, as curriculum alignment is a key criterion in the approval process (Künzli, 2009; Matthes & Heinze, 2005; Wiater, 2005). Höhne (2005, p. 82) characterized this relationship by stating that “curricula contain official and dominant interpretive knowledge, which is then translated into practical terms in textbooks.” Thus, the textbook serves as a translator, mediating between the policy-level specification of what students should know and the practical realities of classroom instruction. This translation process inevitably involves interpretive choices that can either sustain or challenge existing social arrangements, including the gendered division of the occupational world.

The discourse arena perspective thus provides important context for interpreting gender representation in textbooks. Through this lens, the systematic underrepresentation of women in certain occupational domains, or their concentration in stereotypical roles, can be understood not as a neutral description but as reflecting the social processes through which particular representations have been legitimated (Apple, 1993/2014; Höhne, 2003). Such legitimation often operates implicitly. The concept of the “hidden curriculum” (Apple, 1978; Giroux & Penna, 1979; Jackson, 1968; Rossouw

& Frick, 2023) captures this dimension. Beyond the explicit content they convey, textbooks transmit implicit messages through the routine depiction of individuals performing various actions. For example, a textbook does not need to explicitly state that engineering is a male occupation; this message can be conveyed when male characters are systematically associated with technical work whereas female characters predominantly appear in care roles. These cumulative associations constitute a form of implicit knowledge about occupational gender that may influence readers' understanding in ways that explicit instruction does not (Höhne, 2003).

Textbook Representations as Socialization Influences

Beyond being producers and products of discourse, textbooks are media through which social knowledge is communicated to readers. What distinguishes them within the broader media landscape is their institutional sanction and their systematic, repeated deployment across formative developmental periods (Höhne, 2003; Stein, 1991). In contrast to entertainment media, textbooks are used in structured learning contexts. Their state-sanctioned status lends weight to their content such that representations may be perceived as reflecting established knowledge about how the world is organized (Apple, 1993; Bernstein, 2004; Höhne, 2003). Repeated engagement with their content across school years may also reinforce particular associations through cumulative exposure (Olsson & Martiny, 2018; Shehata et al., 2021).

Textbooks are widely considered to be relevant educational media that affect students' learning experiences and their understanding of the world (Apple & Christian-Smith, 1991; Tyson-Bernstein, 1988). Research suggests that the portrayal of social groups and occupational roles in these materials influences students' understanding of social norms, their beliefs, and their identity formation (Behnke, 2018; Curdt-Christiansen, 2017; Lässig, 2010). Although direct empirical evidence for such causal effects remains distinct from these theoretical arguments, a growing body of experimental research supports the proposed link. Studies in psycholinguistics have demonstrated that the use of gender-fair language in occupational descriptions directly influences children's and adolescents' perceptions of those roles (Horvath et al., 2015; Horvath & Sczesny, 2016; Vervecken et al., 2015; Vervecken & Hannover, 2015). For example, Vervecken and Hannover (2015) found that using gender-fair language to describe occupations increased children's self-efficacy ratings for traditionally male-typed occupations. Experimental research has shown that exposure to counter-stereotypical images can affect performance-relevant outcomes (Good et al., 2010) and that stereotype-consistent and stereotype-inconsistent portrayals influence children's occupational aspirations differently (M. S. Ashby & Wittmaier, 1978; Fitzpatrick & McPherson, 2010). In a review of research on gender in children's literature, Diekman and Murnen (2004) concluded that

stereotypical depictions offer children limited opportunities for identification and may constrain their developing sense of appropriate aspirations. Although these studies do not specifically examine textbooks, they establish that symbolic representations of occupational gender can influence cognitions and attitudes, particularly during developmental periods when occupational identities are forming (Korlat et al., 2023; Leaper, 2015).

Since textbook portrayals of occupational roles often reflect traditional gender roles (Arnot, 2002; Moser, 2016; Ott, 2017a), they may perpetuate gender disparities through the implicit signal they send about who belongs in which occupational domains. Taken together, the theoretical and empirical literatures provide a reasonable basis for assuming that textbook representations matter for students' developing occupational knowledge and aspirations (Behnke, 2018; Curdt-Christiansen, 2017). This underscores the importance of research that systematically documents textbook content, which is the focus the following review and of the present dissertation.

Horizontal Segregation in Textbook Representation

Research on gender representation in educational materials emerged in the late 1960s from second-wave feminist critique, pioneered in the German-speaking region by Sollwedel (1967a, 1967b), whose work Fichera (1996) characterized as a paradigm shift in the field.³ The accumulated evidence is reviewed here along the two dimensions central to the present dissertation, with attention to how research on each has developed over time. Of these dimensions, the horizontal has received the most extensive empirical attention, advancing in three phases that have refined the analytical lens and confirming the same underlying finding: women are consistently underrepresented in occupational roles, and where they appear, they are concentrated in a narrow range of female-typed fields.

The earliest content analyses, emerging from the second-wave feminist critique, asked whether women appeared in occupational roles at all, and documented a pronounced female invisibility. In an analysis of 18 American picture books, Weitzman et al. (1972) found a ratio of eleven male to one female depiction and no women in occupational roles. Comparable imbalances were reported across national contexts, with women constituting roughly a quarter of depicted

³ For comprehensive reviews of textbook research on gender representation, see Chisholm (2018), Fichera (1996), Hunze (2003), Mills and Mustapha (2015), Moser (2016), and Ott (2017b). The present review is selective and covers the studies most directly relevant to the three-dimensional framework of this dissertation (horizontal segregation, vertical segregation, and temporal change) and to the analytical questions pursued in Studies I, II, and III.

characters and markedly smaller share of occupational mentions (Karsten, 1976; Marten & Matlin, 1976; Silbermann & Krüger, 1971). These foundational studies established the fact of underrepresentation but treated occupational roles as an undifferentiated category, recording who appeared without asking in which kinds of work.

A second phase moved from counting characters to characterizing the work they performed, and in doing so revealed the structure beneath the frequency gap. When women appeared in occupational roles, they were confined to a narrow band of service and domestic occupations, whereas men populated the full occupational spectrum. Women were portrayed as saleswomen, cooks, domestic servants, and, in later decades, teachers, whereas men appeared across technical, professional, and manual fields (Bühlmann, 2009; Karsten, 1976; Ohlms, 1984). This asymmetry in occupational range was subsequently quantified: men were depicted in two to three times as many distinct occupational categories as women (Hamilton et al., 2006; Jehle et al., 2024; Moser & Hannover, 2014). This phase captured what frequency counts alone had missed, namely that horizontal segregation operates through the breadth of roles open to each gender. Its limitation was conceptual: the recurring categories of “typically female” and “typically male” occupations were defined ad hoc, study by study, without reference to a theoretically grounded account of how labor markets are segregated.

The most recent phase has begun to close this conceptual gap by importing systematic domain classifications, and two distinct approaches are visible. Ott (2017b) developed a scheme of twenty-five activity areas, adapted from the UNESCO Textbook Guide (Brugeilles & Cromer, 2009), and traced the distribution of female- and male-referring occupational terms across these areas over more than a century of German textbooks, finding that male terms spanned far more areas than female terms in every period. A second approach imported the STEM framework. Kerkhoven et al. (2016) found that men constituted 75% of figures in STEM occupations across online science resources, and Zhao and Wotipka (2025) documented the same pattern in Chinese science textbooks, with men shown as scientists and women in caregiving roles.

These approaches mark a clear advance over ad hoc categories, yet neither captures the structure the present dissertation examines. Ott’s activity areas, though systematic, were inductively derived and descriptive; they were not designed to test the bidirectional logic of labor market segregation, in which a male-typed and a female-typed domain are analyzed as complementary poles. The STEM framework captures the male-typed pole but has been applied to online resources and to non-German textbooks, rarely alongside its female-typed counterpart, and the HEED framework, which captures the female-typed pole, has not been applied to textbook representations at all. No

study has applied the paired HEED/STEM framework to German textbooks to ask whether they reproduce the bidirectional structure of labor market segregation, in which women are underrepresented in STEM and men are underrepresented in HEED. This is the first gap the present dissertation addresses.

Vertical Segregation in Textbook Representation

In contrast to the horizontal dimension, the vertical dimension of occupational gender representation, that is, the distribution of women and men across positions of differing status, authority, and qualification, has received only sporadic and largely incidental attention. No study has made it the central object of analysis; the evidence that exists has accumulated as a by-product of research designed for other purposes, and it is concentrated at the linguistic instead of the character level.

The earliest indications appeared within studies primarily concerned with frequency and role confinement. In an analysis of English-language textbooks used in German secondary schools, Hellinger (1980) found not only that men and women occupied different fields but that they occupied different strata: men appeared as engineers, scientists, bankers, and explorers, whereas women were confined to lower-status roles such as waitresses, office workers, and maids, with only two women in the entire corpus shown in positions of high professional standing. Comparable forms of exclusion from positions of authority and prestige were noted in biology and mathematics textbooks (Demes, 1984; Glötzner, 1982). These observations identified the vertical dimension but did not measure it; status appeared as an incidental theme within analyses organized around frequency.

The most sustained engagement with the vertical dimension to date is Ott's (2017b) discourse-linguistic analysis, which traced markers of qualification and hierarchy in occupational terms across more than a century of German textbooks. Ott found that male occupational terms were marked for qualification and leadership from the beginning of the study period, through word-formation elements such as *-meister* and *-leiter* and terms such as *Direktor*, whereas female terms rarely carried morphologically explicit qualifications. Women appeared as assistants (*Helferinnen*) to men, and the first female leadership roles, emerging only in the 1960s, remained confined to education. This is the closest the field has come to a systematic treatment of vertical segregation, yet it operates at the level of the occupational term instead of the character, and it does not assign characters to defined status levels or compare hierarchical positioning across occupational domains.

A related strand examined technical expertise as an implicit marker of status. Finsterwald and Ziegler (2007) found that female characters were predominantly shown in roles requiring minimal technical knowledge, whereas male characters were depicted with moderate to high

technical expertise. Technical competence functions here as a proxy for occupational standing, but expertise and hierarchical position are not equivalent, and this strand again stopped short of coding status directly.

The vertical dimension is therefore the least developed in the field. It has been observed within frequency studies (Hellinger, 1980), analyzed at the linguistic level (Ott, 2017b), and approached through the proxy of technical expertise (Finsterwald & Ziegler, 2007), but it has never been examined through systematic status-level coding of characters across occupational domains, and never with a comparison of textual and visual modalities. Whether textbooks place women and men at different levels of occupational hierarchies, and whether this differs between female-typed and male-typed domains and between text and image, remains an open question. This is the second gap the present dissertation addresses.

Temporal Change and the 1986 KMK Resolution

The third question the field has pursued is whether textbook representations have changed over time, and here two issues must be distinguished. The first is whether representation has improved gradually across the decades. The second is whether specific policy interventions have produced measurable change. The German context offers a rare opportunity to examine the second issue, because the equal treatment of women and men in educational materials was made an explicit policy mandate in 1986.

Longitudinal and cross-generational studies converge on a consistent picture. The general visibility of women in textbooks increased over the decades, whereas the structure of occupational segregation proved far more resistant to change. In the United States, the proportion of female characters in award-winning picture books rose only modestly across the second half of the century (Davis & McDaniel, 1999; McCabe et al., 2011), and references to women in history textbooks increased but remained low (Clark & Mahoney, 2004). German and Swiss studies report the same divergence. Women became more visible overall, yet remained concentrated in a narrow range of occupational roles, with fields such as medicine, law, and the skilled trades staying almost entirely male across the decades studied (Bühlmann, 2009; V. Lindner & Lukesch, 1994; Ott, 2017b). The recurring finding is therefore not stasis but uneven change, in which visibility improved even as the occupational structure held.

A distinctively comparative finding concerns differences between school subjects. Studies that examined mathematics and language arts side by side have repeatedly found mathematics textbooks to be more strongly segregated. V. Lindner and Lukesch (1994) found female occupational representation far lower in mathematics than in German language arts textbooks, Moser and

Hannover (2014) reported men described more frequently relative to women in mathematics than in language arts two decades later, and Jehle et al. (2024) documented the same gap in a recent European sample. This subject-specific pattern aligns with the gendered connotations of mathematics and language arts discussed in Section 2.1, but it has been documented only through comparisons of discrete samples, never modeled as a continuous trajectory that would reveal whether the gap between subjects widened or narrowed.

Against this background the 1986 resolution of the Standing Conference of the Ministers of Education and Cultural Affairs (KMK) acquires particular significance. Issued in the response to the feminist critique of the preceding decades, it mandated the equal treatment of women and men in German educational materials (Fuchs et al., 2010; KMK, 1986). Because it applies to a single national context at a specific point in time, the resolution offers an unusually clear opportunity to test whether a policy mandate can alter representational practice. Yet discussions of its impact have remained at the level of general observation, noting that change after 1986 was slow and uneven without isolating the resolution's specific contribution (Fuchs et al., 2010; Ott, 2016).

The temporal dimension has therefore been studied through comparisons of discrete periods instead of continuous modeling, and no study has employed a design capable of isolating the effect of the 1986 resolution against the background trend, nor tracked domain-specific representation along HEED and STEM lines over time. Whether occupational gender representation changed across six decades of German textbook production, whether this change differed by subject and domain, and whether the 1986 resolution produced a measurable discontinuity, remain open questions. These constitute the third gap the present dissertation addresses.

Research Gaps and Desiderata

The preceding subsections worked out three gaps in the field's understanding of how German textbooks represent the occupational world, one for each dimension central to this dissertation.

On the horizontal dimension, research has documented female underrepresentation and confinement to female-typed roles, and has begun to apply systematic domain classifications, but no study has applied the paired HEED/STEM framework to German textbooks to ask whether they reproduce the bidirectional structure of labor market segregation. On the vertical dimension, the field has noted exclusion from positions of authority and prestige and has analyzed qualification at the linguistic level (Ott, 2017b), but it has not examined hierarchical positioning through systematic status-level coding of characters across occupational domains and across text and image. On the temporal dimension, longitudinal and cross-generational comparisons have documented uneven

change but have not modeled continuous trajectories along HEED and STEM lines, and no study has used a design capable of isolating the effect of the 1986 KMK resolution against the background trend.

Beyond these dimensional gaps, two further aspects of the field warrant attention. Although general education textbooks have received sustained research attention, occupational orientation textbooks have been overlooked, even though they are the materials students encounter during late adolescence when career decisions become concrete, and they are the natural site for examining horizontal segregation in vocational contexts and especially the vertical dimension as it bears on emerging aspirations. Methodologically, answering the dimensional questions at the necessary scale and historical depth has required computational text-analytic approaches that the field has so far applied only to small corpora or to other content questions, and combining such methods with manual character-level coding is what allows the dimensional gaps to be addressed.

The following chapter formulates the research questions that follow from these gaps and presents the three studies designed to answer them.

Chapter 3: Aims and Design of the Research Programme

Aims and Design of the Research Programme

Section 2.2 identified three gaps in the field's understanding of how German textbooks represent the occupational world, one for each of the three dimensions central to this dissertation. From these gaps, three research questions follow:

RQ1 (Horizontal Segregation). Do German textbooks reproduce the bidirectional structure of labor market segregation, in which women are underrepresented in STEM and men are underrepresented in HEED?

RQ2 (Vertical Segregation). Are women and men assigned to different status levels within occupational hierarchies in German textbooks, and does this differ between female-dominated and male-dominated domains and between textual and visual representations?

RQ3 (Temporal Change and the 1986 KMK Resolution). How has horizontal occupational gender segregation in German textbooks changed across six decades, did the trajectory differ between HEED and STEM domains and between gendered school subjects, and did the 1986 KMK resolution produce a measurable discontinuity in representational practice?

The dissertation comprises three studies that together address these questions across multiple textbook types, decades, and modalities. The three studies are reproduced in full in the Appendix; the sections that follow describe how each contributes to the research questions, and Chapter 4 synthesizes the findings from across the studies along the three dimensions.

Addressing RQ1: Horizontal Segregation across Textbook Types and Subjects

Three studies contribute to the analysis of horizontal segregation. Study I provides a large-scale cross-sectional analysis of 202 currently approved German language arts textbooks for primary, lower secondary, and upper secondary schools in Bavaria, comprising 47,842 pages of digitized text. Dictionary-based text analysis identifies the frequency of HEED and STEM occupational terms based on word lists developed from the official occupational classification of the German Federal Employment Agency. A supplementary exploratory collocation analysis additionally examines the adjectives co-occurring with male and female occupational terms, providing initial evidence on whether the agency and communion dimensions are reproduced in textbook language.

Study II extends the analysis longitudinally and across subjects. The corpus comprises 820 textbooks (523 German language arts, 297 mathematics) approved in Bavaria between 1960 and 2017 across the Grundschule, the Mittelschule and Realschule, and the Gymnasium. The same dictionary-based approach as in Study I identifies HEED and STEM occupational terms, and a

binomial generalized linear mixed model estimates female representation as a function of subject, domain, and time.

Study III complements these computational analyses with manual content analysis of 19 occupational orientation textbooks for the Bavarian Mittelschule, approved between 2017 and 2022. All 1,195 character portrayals are coded for occupational domain, distinguishing female-dominated domains (HEED and service occupations) from male-dominated domains (STEM and skilled trades), and analyzed separately for textual and visual modalities.

Addressing RQ2: Vertical Segregation in Occupational Orientation Materials

Study III addresses the vertical dimension. The 1,195 character portrayals are coded for hierarchical status using the three-level classification of the German Federal Employment Agency, which distinguishes helper and unskilled work (low status), skilled work and specialists (medium status), and experts and leadership positions (high status). Analyses are conducted separately for female-dominated and male-dominated domains and for textual and visual modalities, so that vertical segregation is examined in interaction with horizontal positioning and across both representational channels. This is the analytical level at which the dissertation contributes most distinctively to the field, since prior research had examined vertical segregation only at the linguistic level (Ott, 2017b) or through the proxy of technical expertise (Finsterwald & Ziegler, 2007).

Addressing RQ3: Temporal Change and the 1986 KMK Resolution

Study II addresses the temporal dimension. The model fitted to the 820-textbook corpus includes time as a continuous predictor capturing the long-term trend in female occupational representation, a binary post-resolution variable capturing the discontinuity at 1986, and an interaction with subject (language arts and mathematics). This interrupted time series design isolates the effect of the 1986 KMK resolution against the underlying trend and tests whether its effects differed between subjects. To the knowledge of the present author, the design is the first to isolate the resolution's effect statistically, beyond the level of general observation. The temporal analysis is restricted to horizontal segregation. Tracking vertical segregation across the same period would have required manual character-level coding of textbooks across decades, which lay beyond the scope of the present research and is identified as a direction for future research.

The three studies are mutually constitutive. Study I establishes the contemporary scope of HEED and STEM representation in language arts at scale; Study II extends this picture longitudinally and across subjects and tests the policy intervention; Study III brings vertical positioning and visual representations into view through manual coding of occupational orientation materials. Chapter 4

synthesizes their findings along the three dimensions of the research programme. Chapter 5 then discusses the implications, addresses limitations, and outlines directions for future research.

Chapter 4: Empirical Findings

Empirical Findings

Across the three studies, German textbooks depict gainful employment as a predominantly male social role regardless of occupational domain, school subject, textbook type, or historical period. Men were significantly overrepresented in both HEED and STEM occupational roles in 202 currently approved language arts textbooks (Study I), accounted for the substantial majority of HEED and STEM occupational mentions across 820 textbooks spanning 1960 to 2017 (Study II), and outnumbered women across 1,195 character portrayals in occupational orientation textbooks (Study III). This cross-cutting finding holds across three methodologically distinct studies, namely computational text analysis, longitudinal corpus modeling, and manual content analysis, makes it unlikely that any aspect of it reflects the characteristics of a particular corpus or method. The remainder of this chapter reports the dimension-specific findings under the three research questions formulated in Chapter 3.

Horizontal Segregation (RQ1)

The first research question asked whether German textbooks reproduce the bidirectional structure of labor market segregation, in which women are underrepresented in STEM and men are underrepresented in HEED.

Study I, drawing on a corpus of 202 currently approved Bavarian language arts textbooks comprising 47,842 pages of digitized text, used dictionary-based text analysis to identify the frequency of HEED and STEM occupational terms. Women accounted for 26.4% of HEED occupational mentions and only 14.4% of STEM occupational mentions, documenting male overrepresentation in both domains at the level of frequency. Study II, drawing on the 820-textbook corpus from 1960 to 2017, found that women accounted for 17.8% of HEED occupational mentions and only 3.9% of STEM occupational mentions across the period as a whole, reaching 23.1% in HEED by the final period (2006 to 2017) but remaining minimal in STEM throughout. Study III's manual coding of 1,195 character portrayals in occupational orientation textbooks confirmed the pattern at the character level. Female characters constituted 64% of those in female-dominated occupational domains (HEED and service occupations) and only 22% of those in male-dominated occupational domains (STEM and skilled trades), a distribution that closely resembled actual German labor market statistics (Bundesagentur für Arbeit, 2024). The same horizontal asymmetry was evident in both textual and visual modalities of Study III, although the absolute underrepresentation of women was predominantly textual and not visual.

In addition to the frequency analysis, Study I included an exploratory collocation analysis of the adjectives co-occurring with HEED and STEM occupational terms. Agency and communion adjectives were used rarely in connection with HEED and STEM occupational characters of either gender. Where adjectives did appear, their associations were mixed and partly counterintuitive, and occupation-specific adjectives predominated across both domains and both genders. The agency/communion structure documented in social psychological research on occupational gender stereotyping was therefore not directly reproduced in textbook language at the level of explicit attributive description.

Vertical Segregation (RQ2)

The second research question asked whether women and men were assigned to different status levels within occupational hierarchies, and whether this differed between female-typed and male-typed domains and between textual and visual representations.

Study III provided the empirical basis. In textual representations, significant vertical segregation was found in both female-dominated occupational domains (HEED and service occupations) and male-dominated occupational domains (STEM and skilled trades), but the nature of the segregation differed substantially between them. In female-dominated occupational domains, women were disproportionately concentrated at the lowest hierarchical level, comprising 78.7% of all characters at that level, a pattern Berheide (1992) termed the “sticky floor” effect. In male-dominated occupational domains, men outnumbered women at all three hierarchical levels, and there was complete female absence at the lowest level, where no female characters were depicted at all. In visual representations, no significant associations between gender and hierarchical level were found, a null finding that likely reflects the difficulty of conveying hierarchical status through images without accompanying textual cues. The contrasting vertical picture across domains, with women anchored at the bottom of female-typed hierarchies and absent from male-typed ones entirely, holds in textual representations and constitutes the dissertation’s most distinctive empirical contribution.

Temporal Change and the 1986 KMK Resolution (RQ3)

The third research question asked how horizontal occupational gender segregation in German textbooks changed across six decades, whether the trajectory differed along HEED and STEM lines and between gendered school subjects, and whether the 1986 KMK resolution produced a measurable discontinuity in representational practice.

Study II provided the empirical basis. Female occupational representation across the entire corpus from 1960 to 2017 increased from 11.4% to 21.3% in combined mentions across domains

and subjects. This overall increase concealed substantial divergence across domains and subjects that aggregate analyses could not detect. In HEED occupations, female representation increased consistently and substantially throughout the study period. In STEM occupations, the increase was minimal: female STEM representation in mathematics textbooks remained statistically static from 1960 to 2017, moving from 1.4% to 1.0%.

The interrupted time series design identified divergent effects of the 1986 KMK resolution. In German language arts textbooks, female representation showed a positive discontinuity immediately after 1986. In mathematics textbooks, the probability of female occupational mentions declined immediately after the resolution, although the long-term upward trend continued. By the final period (2006 to 2017), the odds of an occupational mention being female were nearly five times higher in German language arts textbooks than in mathematics textbooks, a disparity that did not exist before 1986. To the knowledge of the present author, this is the first empirical demonstration that a major German educational policy intervention produced measurable, subject-specific effects on occupational gender representation.

Across the three dimensions, the empirical findings are consistent: German textbooks reproduce the horizontal structure of labor market segregation and intensify it through the absolute underrepresentation of women in both HEED and STEM; they exhibit pronounced vertical segregation that combines a sticky-floor effect in female-dominated domains with complete female exclusion at the lowest level of male-dominated ones; and they have changed unevenly across six decades, with the 1986 policy intervention producing measurable but subject-specific effects. Chapter 5 takes up the theoretical and practical implications of these findings, addresses the limitations of the present research, and outlines directions for future research.

Chapter 5: General Discussion

General Discussion

The findings reported in Chapter 4 establish a consistent picture across the three studies. Across domains, subjects, textbook types, and historical periods, German textbooks depict gainful employment as a predominantly male social role. The consistency of this finding across three methodologically distinct studies, namely computational text analysis, longitudinal corpus modeling, and manual content analysis, makes it unlikely that it reflects the characteristics of any particular corpus or method. Following Höhne (2003), textbooks function in this respect as a *Konstruktorium*. They do not document occupational reality but selectively construct a version of it in which paid work is encoded as a male domain across all examined dimensions. The present chapter takes up the theoretical and practical implications of these findings, organized by the three research questions formulated in Chapter 3. It addresses horizontal segregation, vertical segregation, and temporal change in turn, then turns to the implications for publishers, policy makers, and teachers, addresses the limitations of the present research, and outlines directions for future research.

The HEED/STEM Gradient: Domain-Specific Horizontal Segregation in Textbook Portrayals

The findings on horizontal segregation address different levels of analysis that together reveal a more complete picture than any single study could produce. At the level of absolute frequency, men were mentioned more often than women in HEED and STEM occupational roles across all textbooks examined (Studies I and II). At the level of relative distribution across domains, female characters were substantially more concentrated in female-dominated domains (64%) than in male-dominated domains (22%), a distribution that closely resembled actual German labor market statistics (Bundesagentur für Arbeit, 2024; Study III). Compared to earlier research on textbooks, which documented the general underrepresentation of women in occupational roles without systematically examining domain-specific distributions (Bühlmann, 2009; V. Lindner & Lukesch, 1994; Moser & Hannover, 2014), the present findings demonstrate that the HEED/STEM structure of labor market segregation is accurately reflected in educational materials, a level of detail that prior non-systematic categorizations could not capture.

The two domains tell different stories about the nature of this reproduction. Within HEED occupations, women comprised 17.8% of occupational mentions across 820 textbooks (Study II), whereas they constituted 64% of characters in female-dominated occupational domains in vocational orientation materials (Study III). The first figure shows the continued absolute underrepresentation of women, even in fields where they make up the majority of the workforce. The

second figure shows that female characters were at least relatively concentrated in HEED domains, which approximate labor market distributions. Within STEM occupations, by contrast, women comprised only 3.9% of occupational mentions across the same corpus (Study II), and male characters dominated male-dominated occupational domains in vocational orientation materials at all hierarchical levels (Study III). This near-complete absence extends to German textbooks for the first time the pattern documented in prior research on STEM representation in educational materials. Compared to Kerkhoven et al. (2016), who found that 75% of individuals depicted in science occupations across online science education resources were men, and Zhao and Wotipka (2025), who found only one female scientist depicted across 149 images in Chinese middle school science textbooks, the present findings extend these results to German general and vocational education textbooks across a large, representative corpus. The gap between the two domains is informative in itself. Women were mentioned more than four times as frequently in HEED as in STEM occupational roles (17.8% versus 3.9%). This gradient is not random. It reflects the structure of occupational gender segregation in the labor market, and it indicates that horizontal segregation in textbooks does not operate as a uniform suppression of female representation. It operates instead as a domain-specific distribution that may entrench the gendered sorting students encounter in the occupational world.

The male dominance of HEED occupations merits closer examination because it contradicts expectations based on labor market composition and prior textbook research. Earlier research had consistently found an overrepresentation of women in care-related roles in textbooks (Bühlmann, 2009; Finsterwald & Ziegler, 2007; Ott, 2021). These analyses, however, relied on non-systematic categories such as “typically female occupations” instead of the HEED classification used here. Using a systematic domain classification revealed a reversal of this finding. Men outnumbered women in health, education, and care roles in currently approved language arts textbooks (Study I). This reversal is somewhat surprising. One possible explanation is that the HEED classification captures a broader range of occupational roles than non-systematic categories, including medicine and professorial occupations, which have historically been male-dominated in both the labor market and in educational materials even within the care sector (Bundesagentur für Arbeit, 2021; V. Lindner & Lukesch, 1994). A second possibility is that the computational approach, which counts occupational term frequencies and not individual character portrayals, amplifies the visibility of high-frequency occupational labels such as doctor and teacher, which appear in multiple contexts across a textbook corpus regardless of domain coding. These explanations are not mutually exclusive, and future research combining computational frequency analysis with manual character-level coding could

clarify their relative contribution. The finding unambiguously indicates that the underrepresentation of women in textbooks is not offset by their overrepresentation in traditionally feminine domains, as earlier research might have suggested. The full scope of this construction, extending across all domains including those where women dominate the actual workforce, is interpretable through the lens of the hidden curriculum (Apple, 1978; Giroux & Penna, 1979; Jackson, 1968; Rossouw & Frick, 2023). Alongside what textbooks explicitly teach about occupations, the cumulative distribution of who appears in which roles implicitly communicates a message about the gendered structure of the occupational world, a message that requires no explicit endorsement to be understood (Curd-Christiansen, 2017; Höhne, 2003).

This distribution is consistent with Social Role Theory's explanation of how gender stereotypes are perpetuated (Eagly, 1987; Eagly & Wood, 2012). By depicting women primarily in HEED and service roles and men primarily in STEM and skilled trades roles, textbooks provide exactly the kind of repeated role-based observations that Social Role Theory identifies as the source of descriptive stereotypes, namely beliefs about how women and men typically behave and which occupations are appropriate for each gender (Eagly et al., 2000; Prentice & Carranza, 2002). From a gender schema theory perspective (Bem, 1981; Martin & Halverson, 1981; Starr & Zurbriggen, 2017), exposure to these gendered occupational distributions may strengthen the cognitive schemas through which children organize incoming information about gender and occupation. This makes it more likely that children will notice and remember gender-consistent occupational information and overlooking counter-stereotypical representations (Starr & Zurbriggen, 2017). Counter-stereotypical representations can positively influence girls' engagement and performance in STEM (Good et al., 2010; Olsson & Martiny, 2018), whereas the near absence of female role models in STEM textbook portrayals perpetuates the perception that STEM is a male domain (J. Lindner & Makarova, 2024). Similar effects have been documented for boys in care work domains. The absence of male role models in HEED occupations may constrain boys' engagement in these fields (Puzio & Valshtein, 2022). The present research contributes to prior textbook studies by examining the bidirectional nature of these findings, namely the male underrepresentation in HEED alongside the near absence of females in STEM (Croft et al., 2015; England, 2010). Most prior studies focused on female underrepresentation without examining whether male underrepresentation in care-related domains is equally reproduced in educational materials (Bühlmann, 2009; Finsterwald & Ziegler, 2007; V. Lindner & Lukesch, 1994; Moser & Hannover, 2014; Ott, 2021).

The findings of Study III on gender-fair language add a further dimension to this picture. Despite the use of this form of language in 38% of all character portrayals in occupational orientation

textbooks, pronounced horizontal segregation persisted (Study III). Linguistic inclusivity alone is therefore insufficient to counteract occupational stereotypes embedded in the domain structure of portrayals (Sczesny et al., 2016; Vervecken & Hannover, 2015). This finding builds on existing literature on the effects of gender-fair language (Stahlberg et al., 2007; Cruz Neri & Siems-Muntoni, 2026), which has shown that linguistic form influences perceptions of occupational gender typicality (Vervecken & Hannover, 2015; Vervecken et al., 2013). It demonstrates that these effects occur within a representational context that independently sustains segregation through domain distribution. Analyses focusing exclusively on language use (Kiesendahl & Ott, 2015; Moser & Hannover, 2014), without examining the occupational domain and hierarchical position of characters, may therefore substantially underestimate the scope of gender-stereotypical representation in educational materials.

In addition to the frequency analyses, Study I included an exploratory collocation analysis examining whether the adjectives used to describe HEED and STEM characters drew on the gender-stereotypical attribute dimensions of agency and communion. Contrary to prior expectations (Abele & Wojciszke, 2007; Pietraszkiewicz et al., 2019), agency and communion adjectives were used rarely for both HEED and STEM occupational characters. Where adjectives appeared, their associations were mixed and partly counterintuitive, and occupation-specific adjectives predominated across both domains and both genders. This finding suggests that the agency/communion structure documented in social psychological research on occupational gender stereotyping (Eagly et al., 2020; Korlat et al., 2022, 2023; Pietraszkiewicz & Formanowicz, 2023; Pietraszkiewicz et al., 2019) is not directly reproduced in textbook language at the level of explicit attributive description. Given the exploratory nature of this analysis and the absence of comparable measures in Studies II and III, the question of how the agency and communion dimensions are encoded linguistically in textbooks is taken up further in the directions for future research.

Sticky Floors and Absent Women: Vertical Segregation across Occupational Hierarchies

Prior German textbook research has lacked a systematic examination of the vertical dimension of occupational gender representation. Although earlier work noted disparities in technical expertise between female and male characters (Finsterwald & Ziegler, 2007) and analyzed qualification and hierarchy markers at the linguistic level (Ott, 2017b), these observations remained largely fragmented. Hierarchical positioning had not been examined systematically through character-level coding across occupational domains and representational modalities. The present findings fill this gap and reveal a picture that differs substantially from what labor market and prior

textbook research would predict. No significant associations between gender and hierarchical level were found in visual representations, likely owing to the difficulty of conveying hierarchical status through images without accompanying textual cues (Stanczak, 2007). In textual representations, significant vertical segregation was found in both female-dominated occupational domains and male-dominated occupational domains, although the nature of the segregation differed substantially between them (Study III).

In female-dominated fields, textbooks demonstrated what Berheide (1992) termed the “sticky floor” effect. Women were disproportionately concentrated at the lowest hierarchical level, comprising 78.7% of all characters at that level. Unlike the glass escalator effect, where men in female-dominated fields often advance more quickly than their female colleagues (International Labour Office & World Health Organization, 2022; C. L. Williams, 1992, 2013), the textbook depiction reverses this dynamic. Women were concentrated at the entry level, whereas men were distributed across all hierarchical levels. In male-dominated fields, men outnumbered women at all three levels. There was complete male domination at the lowest level, where no female characters were depicted at all. To the knowledge of the present author, this complete exclusion is unprecedented in prior textbook research and constitutes a finding specific to the vertical dimension that the field’s prior focus on horizontal segregation and general visibility could not have produced. The contrasting vertical picture across domains, with women anchored at the bottom of female-dominated hierarchies and absent from male-dominated ones entirely, may reflect what Sinclair and Carlsson (2013) termed “selective progressiveness”, namely the appearance of female inclusion within acceptable feminine domains that coexists with the maintenance of rigid boundaries within masculine ones. From a Situated Expectancy-Value perspective (Eccles & Wigfield, 2020; Wigfield & Eccles, 2000), exposure to these representations may shape girls’ and women’s developing self-concepts and self-efficacy beliefs. These representations suggest that even within female-dominated fields, high-status positions are predominantly male territory and that male-dominated occupational domains are entirely closed to women. This dual message may reduce the expectation of success and the subjective task value of a broad range of occupational choices (Correll, 2001; Else-Quest et al., 2010; Steffens & Jelenec, 2011).

These occupational orientation materials are used during adolescence, which is precisely the developmental period when Gottfredson’s (1981, 2002, 2020) circumscription processes may translate into concrete career decisions (Haasler, 2020; Korlat et al., 2022, 2023). Gottfredson’s model identifies gender-type boundaries as the first and most durable form of circumscription. They are established between the ages of six and eight and are highly resistant to later revision (Helwig,

2001; Henderson et al., 1988). The vertical segregation documented here adds a dimension to this account that prior research had not examined. For young women, the combination of horizontal concentration in female-dominated fields and the sticky floor effect within those fields may suggest that career advancement is possible only within traditional feminine boundaries and at lower hierarchical levels, thereby narrowing the scope of acceptable aspirations along horizontal and vertical axes simultaneously. For young men, consistent association with male-dominated fields across all levels of the hierarchy and the complete absence of women at the entry level of these fields may consolidate expectations of advancement across the full hierarchy. These messages, encountered through state-sanctioned materials during the period when circumscription translates into training and course selection decisions, constitute the informational environment in which occupational aspirations narrow. According to gender schema theory (Bem, 1981; Martin & Halverson, 1981; Starr & Zurbriggen, 2017), children and adolescents attend to and remember gender-consistent information more readily than gender-inconsistent information. This means that the gendered occupational representations documented here may be selectively encoded in ways that compound the circumscription process, instead of merely reflecting it (Frawley, 2008; Trepanier-Street & Romatowski, 1999).

Six Decades of Textbook Production: Divergent Trajectories and the Effects of the 1986 KMK Resolution

To the knowledge of the present author, Study II provides the first longitudinal evidence of how domain-specific occupational gender representation, distinguished along HEED and STEM lines, evolved across nearly six decades of German textbook production. It is also the first empirical test, using an interrupted time series design, of whether the 1986 KMK resolution produced measurable effects. Previous longitudinal studies have documented changes in general character visibility over time (V. Lindner & Lukesch, 1994) and changes in occupational language use over a longer historical period (Ott, 2017b). However, these studies did not use domain-specific occupational classifications comparable to HEED and STEM, nor did they employ a statistical design capable of isolating the effects of a specific policy intervention. Overall, female occupational representation increased across the study period as a whole, rising from 11.4% to 21.3% in combined mentions across domains and subjects. This overall increase is consistent with earlier longitudinal research documenting gradual improvements in women's general visibility in educational materials (Hamilton et al., 2006; V. Lindner & Lukesch, 1994; Ott, 2017b) and confirms the impact of feminist critiques in the 1970s and 1980s (Acker, 1987; Sollwedel, 1968, 1971) and subsequent policy responses. The overall trend, however, concealed substantial divergence across domains and subjects that aggregate analyses

could not detect. In HEED occupations, female representation increased consistently and substantially throughout the study period. In STEM occupations, the increase was minimal. Female STEM representation in mathematics textbooks remained statistically static from 1960 to 2017, moving from 1.4% to 1.0%. This stagnation contrasts sharply with developments in the actual labor market, where women's participation in STEM fields increased substantially during the same period (Bundesagentur für Arbeit, 2019; England et al., 2020). It also contrasts with the improvement observed in HEED representation within the same corpus. This suggests that the general upward trend documented in earlier longitudinal studies (Finsterwald & Ziegler, 2007; V. Lindner & Lukesch, 1994; Ott, 2017b) obscured domain- and subject-specific divergences that the analyses, which relied on aggregate character counts and not on domain-classified occupational terms, were not designed to capture.

The 1986 KMK resolution produced divergent effects. In German language arts textbooks, female representation increased immediately after 1986. In mathematics textbooks, the probability of female occupational mentions declined immediately after the resolution, although the general upward trend continued over time. The decline in mathematics textbooks immediately after the resolution was unexpected and warrants discussion. It is possible that the resolution, by making gender equality an explicit policy concern, triggered greater awareness among language arts authors and publishers and simultaneously entrenching the masculine-coded identity of mathematics as a domain resistant to such concerns. It is also possible that the decline reflects a short-term disruption in publication patterns immediately following the policy, with the mathematics textbook market adjusting differently and more slowly than the language arts market. Both explanations remain speculative in the absence of qualitative evidence about production practices at that time. Future research combining corpus analysis with archival investigation of publisher records and approval committee documentation could shed light on the mechanism. By the final period (2006 to 2017), the odds of an occupational mention being female were nearly five times higher in German language arts textbooks than in mathematics textbooks, a disparity that did not exist before 1986. To the knowledge of the present author, this divergence is the first empirical demonstration that a major German educational policy intervention produced measurable, subject-specific effects on occupational gender representation. Previous discussions of the KMK resolution's impact remained at the level of general observation, noting that change was slow and uneven. They lacked the statistical infrastructure to isolate the resolution's specific contribution (Fuchs et al., 2010; Ott, 2016). The interrupted time series design employed here enables this isolation for the first time,

revealing that the resolution's effects were not merely slow but also structurally divergent across subjects.

A further consideration concerns the timing of effects. Following Ott (2017b), textbooks function as transmitters of consolidated societal knowledge in their domain of values and norms. This view leads to the prediction that policy interventions targeting representational practice produce delayed effects, not immediate ones, as production cycles adapt and authors internalize new conventions. The positive discontinuity in language arts immediately after 1986 is therefore notable, since it suggests that the language arts production milieu responded comparatively quickly to the policy mandate, faster than Ott's framing would predict. The opposite pattern in mathematics, a decline immediately after 1986, runs against both the Ott prediction and the direction of the resolution itself. This strengthens the interpretation that subject-specific institutional norms within the mathematics textbook production process mediated the resolution's reception, instead of merely slowing it.

These subject-specific divergences demonstrate the intricate ways in which policy mandates are interpreted and executed within various curricular settings (Herrmann, 2016; Matthes et al., 2024; Ott, 2016). Mathematics is culturally coded as masculine and associated with masculine-rational attributes. Language arts, in contrast, is coded as feminine and associated with feminine-expressive attributes (Colley & Comber, 2003; Kollmayer et al., 2017; Nosek et al., 2002; Plante et al., 2009). From a discourse arena perspective (Höhne, 2003, 2005), the production of textbooks involves numerous actors, including authors, publishers, subject experts, and approval committees. These actors' gender beliefs and subject-specific norms mediate the translation of policy into content. Authors and publishers working within a masculine-coded subject context may be more likely, whether consciously or unconsciously, to select occupational content that aligns with existing gender stereotypes. This produces content that preserves the gendered associations of the subject without challenging them (Höhne, 2003; Ott, 2016) and creates a self-reinforcing cycle in which the gender stereotypes embedded in mathematics textbooks simultaneously contribute to and are a product of the subject's masculine culture (Young & Muller, 2016). This finding extends the account of stereotype change in Social Role Theory, which predicts that gender stereotypes shift as the actual distribution of women and men across roles changes (Diekmann & Eagly, 2000; Eagly et al., 2020). However, the near-complete stagnation of female STEM representation in mathematics textbooks over six decades points to a form of subject-specific structural resistance that existing formulations of the theory do not fully address. The present findings point toward the need for a more complete

account, one that would integrate Social Role Theory with an institutional perspective on academic subjects capable of explaining why stereotype resistance is subject-specific.

Implications for Publishers, Policy Makers, and Teachers

The present findings suggest that achieving gender-equitable representation in textbooks requires sustained effort that addresses multiple dimensions simultaneously. Numerical parity in the frequency of female and male characters in occupational roles is a necessary but insufficient condition. The horizontal distribution across occupational domains and the vertical distribution across hierarchical levels must be addressed deliberately and distinctly (Moser, 2016; Ott, 2021). Two findings reveal the most urgent gaps. First, female representation in STEM occupations reached only 1.0% in mathematics textbooks by the end of the study period. Second, women were entirely absent from the lowest hierarchical level in male-dominated occupational domains in vocational orientation materials. Subject-specific measures are therefore needed, since progress in one subject area does not automatically transfer to others (Zala-Mezö et al., 2021). Mathematics textbook publishers and authors should systematically depict women in STEM occupational roles, such as engineers, programmers, and laboratory scientists, in applied tasks and real-world scenarios that connect mathematical content to occupational life. They should also portray women in leadership and expert positions across all occupational domains, including traditionally female-dominated ones. Introducing male characters in HEED roles would address the bidirectional nature of occupational gender segregation documented by the present research (Block et al., 2019; Puzio & Valshtein, 2022). The goal is not to reverse occupational gender portrayals entirely, but to present a variety of role models that reflect the range of occupational opportunities available to all students (Diekmann & Murnen, 2004; Trepanier-Street & Romatowski, 1999).

The divergent effects of the 1986 KMK resolution, which were measurable in language arts textbooks but absent in mathematics textbooks, suggest that broad general mandates may have different impacts depending on the institutional context of the subject in which they are implemented (Herrmann, 2016; Matthes & Schütze, 2016). Guidelines specific to each subject for achieving gender-equitable occupational representation, accompanied by systematic monitoring and formative evaluation during the textbook production process, may be more effective than general mandates applied uniformly across subjects (Zala-Mezö et al., 2021). The finding that the resolution produced a positive discontinuity in language arts but a decline in mathematics immediately after 1986 also raises questions about implementation mechanisms. Future policy interventions should provide subject-specific guidance for textbook authors and publishers, instead of leaving the interpretation

of general equity mandates to individuals whose own subject-specific beliefs and institutional norms may hinder progress.

The persistence of stereotypical occupational representations across textbook types and historical periods highlights the importance of critically engaging with instructional materials in the classroom. Instead of treating textbooks as transparent conveyors of objective information about the occupational world, teachers can use the gendered representations identified in this research as the basis for explicit classroom analysis (Kostas, 2023; Liu, 2006). Highlighting the systematic associations between gender and occupational roles, including the near absence of women in STEM portrayals, the relegation of women to the lowest hierarchical levels in female-dominated fields, and the exclusion of women from male-dominated occupational domains, can foster students' critical media literacy. Doing so encourages students to question the assumptions embedded in their learning materials, particularly in occupational orientation contexts, where the implications for their career aspirations are most direct (Apple & Christian-Smith, 1991; Gottfredson, 2020; Sadker et al., 2009; Zittleman & Sadker, 2002).

Limitations

The interpretation of the present findings is bounded by several limitations, which divide along methodological, scopal, and temporal lines.

Methodologically, the computational approach used in Studies I and II identified occupational terms in running text and could not distinguish between a single character mentioned multiple times and multiple unique characters. A character mentioned many times therefore contributed more to the frequency count than a character mentioned once, which limits conclusions about the number of distinct female and male characters represented in occupational roles. Related to this, Studies I and II captured text only and excluded visual representations. The modality comparison in Study III showed that the underrepresentation of women was predominantly a textual phenomenon, but visual analysis methods capable of capturing subtle status indicators such as dress, setting, and spatial positioning remain underdeveloped in textbook research (Stanczak, 2007). At a more fundamental conceptual level, all three studies were limited to binary gender operationalizations, reflecting the grammatical structure of German occupational terms but failing to capture the full spectrum of gender identity as understood in contemporary theory (Hyde et al., 2019; Schmader & Nater, 2025). The studies likewise did not address how gender intersects with class, race, ethnicity,

or other social categories that jointly shape occupational representation in educational materials (Chisholm, 2018).

In terms of scope, the corpora were drawn from Bavaria, which has a centralized state approval system. Whether these findings generalize to other German federal states with different approval procedures remains unknown (Ott, 2016; Stöber, 2010), and whether comparable patterns characterize other national contexts is similarly open. Case studies across diverse educational systems (Mills & Mustapha, 2015) and recent European samples (Jehle et al., 2024; van de Rozenberg et al., 2023) suggest both convergences and divergences across European educational systems but no comparable longitudinal HEED-STEM analysis has been conducted outside Germany. A further scope limitation concerns the relationship between textbook content and student exposure. The findings document what textbooks contain but not how teachers and students engage with that content. Pedagogical practice varies substantially in the role textbooks play, ranging from primary source of instruction to optional resource for independent work (Gräsel, 2010; Hansen, 2018; Horsley & Sikorová, 2015), so the influence of textbook representations on students depends on instructional mediation that the present design does not capture.

Temporally, the longitudinal analysis was restricted to horizontal segregation. Tracking vertical segregation longitudinally across the same six decades would have required manual character-level coding of an extensive textbook corpus, which lay beyond the scope of the present research.

Directions for Future Research

The present findings open several directions for future research, some addressing the limitations identified above and others extending the empirical and theoretical questions raised by the results.

Methodological extensions follow most directly from the limitations of the present design. Character-level text analysis that identifies and tracks individual characters across a textbook would determine whether the domain-specific findings documented here remain consistent when each character is counted only once. Systematic visual analysis of status indicators in textbook illustrations would complement the textual focus of Studies I and II, particularly given the textual-visual asymmetry documented in Study III. Methodologies capable of identifying non-binary and gender-diverse representations in textbook corpora should also be developed (Alter et al., 2021; Cruz Neri et al., 2024; Koster et al., 2025).

Scopal extensions are equally important. Extending the longitudinal analysis beyond 2017 would allow examination of whether recent societal changes and growing public discourse about

gender equality have begun to affect newly approved textbooks (Eagly et al., 2020). Cross-national extension of the present design to other educational systems would test whether the domain-specific patterns documented here are particular to Germany or reflect broader features of European textbook production (Jehle et al., 2024; van de Rozenberg et al., 2023). Integrating horizontal and vertical segregation analyses into general education textbooks across subjects and tracks is an important next step, since vertical segregation was examined only in vocational-track occupational orientation materials. Tracking vertical segregation longitudinally is a particularly important extension, since the temporal analysis was restricted to horizontal segregation. Linking textbook content to student outcomes through classroom observation or experimental designs would further address the pedagogical-mediation gap noted above.

Beyond the directions tied directly to limitations, three further questions warrant attention. Analyzing gender-fair language use in relation to occupational domain and hierarchical positioning would complement the analyses conducted here (Kiesendahl & Ott, 2015; Pöschko & Prieler, 2018; Sczesny et al., 2016; Vervecken et al., 2013). The exploratory collocation analysis in Study I raised the question of how the agency and communion dimensions, which are central to occupational gender stereotyping in experimental research (Abele & Wojciszke, 2007, 2018; Korlat et al., 2023; Sczesny et al., 2018), are encoded in textbook language. A systematic investigation of grammatical mechanisms such as transitivity (Nuttall, 2019) or verbs (Formanowicz et al., 2017), in addition to attributive language, would substantially advance the understanding of how textbooks construct occupational gender. Most consequentially, whether exposure to the content documented in this dissertation influences students' occupational aspirations, self-efficacy beliefs, and career decisions remains an open empirical question (Behnke, 2018).

Conclusion

The overarching question guiding this dissertation, whether German textbooks reflect, reproduce, or contest the occupational gender segregation documented in contemporary labor markets, is answered consistently across all three studies. Textbooks reproduce and in some respects intensify the gendered occupational arrangements of the world they purport to describe. Women are underrepresented in occupational roles in German school textbooks. They are concentrated in female-dominated domains and restricted to lower-status positions within those domains. Over the past six decades, meaningful change has occurred in only a subset of subjects and domains, leaving female representation in STEM fields virtually unchanged in mathematics textbooks since 1960. These findings document the content of materials that accompany students during critical developmental periods when gender schemas form, academic self-concepts solidify, and

occupational aspirations narrow (Gottfredson, 2002, 2020; Martin & Ruble, 2004; Trautner et al., 2005). Transforming this content is a necessary step toward creating an educational environment that expands the occupational possibilities available to all students.

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Appendix

The three studies that constitute the empirical foundation of this dissertation have been published in peer-reviewed journals. They are reproduced in the following pages in full.

Appendix A: Study I

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

Fruehwirth, B., Heilemann, M., & Stoeger, H. (2024). The gender representation of women and men in the occupational areas of STEM and care work in German textbooks. *Linguistics and Education*, 80, 101284. <https://doi.org/10.1016/j.linged.2024.101284>



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

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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 work¹ 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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¹ 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,² 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 (Kocher 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

² 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 (Vervecken & Hannover, 2015; Vervecken 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,³ 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 (Carroll & 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

³ 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; Vervecken et al., 2015; Vervecken & 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 Abbyy 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	n
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 collocations 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 collocations. 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 $\chi^2(1, N = 8378) = 47.07$, $p < .001$. 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		<i>n</i>	Log Likelihood	<i>MI3</i>	female		<i>n</i>	Log Likelihood	<i>MI3</i>
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
eigeweih	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	astronomical	systematisch	systematic
								botanisch	botanical		
								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	Care work male									
		ausgebildet	trained	besserwisserisch	know-it-all	berufstypisch	professionally	schwindsüchtig	consumptive	schwindsüchtig	skeptical
		angepasst	adapted	streng	strict			schwindelfrei	free from giddiness	schwindelfrei	free from giddiness
		angemessen	appropriate	feige	cowardly			verwitwet	widowed	verwitwet	widowed
		lehrhaft	didactic	obergescheit	know-it-all			deutsch	German	deutsch	German
				wirkungslos	ineffective			Plastisch	plastic	Plastisch	plastic
								katholisch	catholic	katholisch	catholic
								anwesend	present	anwesend	present
								geboren	born	geboren	born
mutig tätig	brave active	Care work female									
		mutig	brave	bedauernd	regretfully	medizinisch	medical	weltlich	secular	weltlich	secular
		verehrwürdig	worshipful	unglaubwürdig	untrustworthy	chirurgisch	surgical	priesterlich	priestly	priesterlich	priestly
		fachgerecht	professional			ärztlich	medical	diakonisch	diaconal	diakonisch	diaconal
		gelemt	learned			orthopädisch	orthopedic	französisch	French	französisch	French
		schmerzlindernd	pain-relieving			pharmazeutisch	pharmaceutical				
						professorial	professorial				
						physikalisch	physically				

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; Verweken 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.

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Declaration of competing interest

None.

Data availability

The authors do not have permission to share data.

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Appendix B: Study II

Gender representation in HEED and STEM occupations: A longitudinal analysis of German language arts and mathematics textbooks (1960–2017)

Fruehwirth, B., Wengler, D., Heilemann, M., & Stoeger, H. (2026). Gender representation in HEED and STEM occupations: A longitudinal analysis of German language arts and mathematics textbooks (1960–2017). *Sex Roles*, 92, Article 21.

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Gender Representation in HEED and STEM Occupations: A Longitudinal Analysis of German Language Arts and Mathematics Textbooks (1960–2017)

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Abstract

Gender stereotypes in educational materials can influence children's and adolescents' career aspirations, contributing to persistent occupational gender segregation. However, large-scale, longitudinal studies examining gender representation in stereotypical occupational domains in textbooks across different school subjects remain scarce. This study addresses this gap by analyzing the gender representation in two key occupational domains: science, technology, engineering, and mathematics (STEM) and health care, early education, and domestic work (HEED) across 820 German language arts and mathematics textbooks from 1960 to 2017. Using a binomial generalized linear mixed model with a discontinuity design we tested how representation was related to time, the 1986 governmental resolution on gender equity, subject area, and occupational domain. Results revealed substantially lower female representation in STEM than HEED occupations throughout the study period. Female STEM representation increased from 0.0% to 9.1%, while HEED representation increased from 12.2% to 23.1%. The 1986 resolution had divergent effects across subjects: female representation increased in German language arts textbooks but decreased in mathematics textbooks. A significant three-way interaction revealed that temporal changes in female representation relate to both subject area and occupational domain. In German language arts textbooks, female representation increased in both HEED and STEM domains, while in mathematics textbooks, female HEED representation increased (from 7.4% to 20.5%), but female STEM representation remained stable (from 1.4% to 1.0%). After 1986, the odds of a STEM occupation mention being female were almost six times higher in German language arts than in mathematics textbooks. These findings demonstrate that progress toward gender-equitable representation is context-dependent, with mathematics textbooks perpetuating stronger occupational stereotypes.

Keywords Gender representation · Occupational segregation · HEED · STEM · Textbook analysis · Longitudinal trend

Contemporary occupational gender segregation is characterized by pronounced disparities between two polarized domains: the occupational domain of science, technology, engineering, and mathematics (STEM) and the occupational domain of health care, early education, and domestic work (HEED) (Charles & Bradley, 2009; Croft et al., 2015; England, 2005). Across industrialized nations, women only constitute approximately 17% of the STEM workforce while

representing over 70% of the HEED workforce, creating gender wage gaps and limiting career mobility (Bundesagentur für Arbeit, 2024; National Science Board & National Science Foundation, 2024; World Health Organization, 2024).

This segregation reflects pervasive cultural associations between these occupational domains and gender-stereotypical attributes (Froehlich et al., 2020). Gender-typed occupational aspirations emerge during childhood and adolescence, when individuals form career-relevant identities that predict later educational and occupational choices (Eccles, 2009, 2011; Fagot et al., 2000; Wicht et al., 2022). Social role theory (Eagly, 1987; Eagly & Wood, 2012) explains this pattern through the cyclical relationship between occupational observations and stereotype formation. Repeated societal observations of women and men in distinct roles create

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strong gender-occupation associations that become culturally embedded over time.

Educational textbooks represent influential sources of occupational gender messages during these formative periods. Textbooks serve dual functions as pedagogical tools and cultural transmitters, communicating implicit messages about occupational gender appropriateness through visual representations, narrative choices, and linguistic patterns (Apple, 1987; Höhne, 2005; Ott, 2016). Research shows that exposure to counter-stereotypical representations in learning materials improves girls' performance and engagement in STEM domains (Good et al., 2010). Furthermore, gender-neutral occupational language has a significantly positive influence on career perceptions, compared to gender-stereotypical language, particularly in grammatically gendered languages like German (Liben et al., 2001; Verweken et al., 2013, 2015). However, not only occupational domains, but also school subjects are associated with gendered connotations. For example, mathematics is a stereotypical masculine school subject, and language arts is a stereotypical feminine school subject (Plante et al., 2009). Thus, textbooks in different subject areas might potentially amplify occupational gender messages (Plante et al., 2009; van der Vleuten et al., 2016).

While previous textbook studies have documented imbalances in gender representation, systematic examination of gender representation in specific occupational domains related to contemporary occupational segregation remains rare. First, most studies rely on simplistic 'typically male/female' categorizations rather than focusing on theoretically meaningful domains like HEED and STEM (Fruehwirth et al., 2024; Ott, 2017b). Second, only a few studies employ longitudinal designs capable of capturing representational changes over extended periods (Finsterwald & Ziegler, 2007; Lindner & Lukesch, 1994; Ott, 2017b). Finally, comparative research examining subject-specific variation in occupational portrayals remains underdeveloped, despite evidence that different school subjects perpetuate distinct gender stereotypes (Moser & Hannover, 2014).

The present study addresses these limitations by examining female and male HEED and STEM occupational representations as indicators of how established gender segregation patterns manifest in mathematics and German language arts books over time. Using computational text analysis of 820 German textbooks spanning 1960–2017, we systematically examine how proportional representation within these occupational domains has evolved across textbooks in these subject areas. Rather than measuring underlying stereotype dimensions, such as typical male or female, we analyze forms of representation that reflect broader HEED and STEM segregation trends, providing empirical evidence regarding educational materials' potential role in reinforcing or challenging occupational gender associations during critical developmental periods.

Gender Stereotypes and Their Role in Occupational Segregation

Gender functions as a fundamental structural and social category that profoundly shapes contemporary societies (Aulenbacher, 2008; Deaux, 1984; Risman, 2004; Schmader & Nater, 2025; West & Zimmermann, 1987). Central drivers are gender stereotypes, which are culturally embedded cognitive schemas that encompass societal beliefs about attributes, characteristics, and behaviors perceived as either typical or appropriate for women and men (Ashmore & Del Boca, 1979; Eckes, 2004). These stereotypes significantly influence individual experiences, opportunities, and life paths, with particularly pronounced effects on occupational aspirations and choices (Watt, 2010).

Gender stereotypes include both descriptive elements (indicating how women and men are typically perceived) and prescriptive elements (defining how women and men are expected to behave) (Eagly & Wood, 2012; Prentice & Carranza, 2002). This dual nature means they not only reflect observed patterns but also create expectations that guide behavior. Through socialization, individuals often internalize these stereotypes, perpetuating gendered societal structures and constraining occupational pathways to those deemed gender-appropriate (Schneider, 2005).

Social role theory (Eagly, 1987; Eagly & Wood, 2012) explains how gender stereotypes emerge and persist through societal observations of women and men occupying distinct social roles. Repeated observations create strong associations between role-based behaviors and inherent gender attributes, eventually embedding these stereotypes culturally (Eagly et al., 2020). Historical societal frameworks, particularly the gendered division of labor and the public-private dichotomy (Rubin, 1975; Weber, 2019) positioned women and men within specific occupational spheres, reinforcing stereotypical attributes. Such divisions contributed to what Hausen (1976) termed a "polarization of gender characters," creating deeply ingrained associations that inform perceptions of occupational gender-appropriateness and drive contemporary occupational segregation patterns (Klinger, 2012).

The Two Poles of Occupational Segregation: HEED and STEM

Occupational gender segregation—the tendency for women and men to work in distinct occupational domains and industries—remains a key characteristic of labor markets worldwide (Charles & Bradley, 2009; Charles & Grusky, 2004; Levanon & Grusky, 2016; Lippa et al., 2014; Wong & Charles, 2020). This segregation closely aligns with societal

gender roles and associated stereotypes, perpetuating disparities in pay, status, and career progression opportunities (England, 2010; Ridgeway, 2011). Particularly illustrative of this gendered occupational divide are two domains that represent extreme poles of gender segregation: health care, early education, and domestic work (HEED) and science, technology, engineering, and mathematics (STEM) (Croft et al., 2015; Stewart-Williams & Halsey, 2021; Tellhed et al., 2017).

HEED domains encompass occupations primarily centered around care, nurturing, education, and social support (Croft et al., 2014, 2015). HEED occupations include roles in health care (e.g., nursing, social work), early education (e.g., preschool, elementary education, childcare), and domestic work (e.g., household management). These roles represent key forms of care work, defined as activities involving the support, development, and welfare of individuals, that fulfill essential functions related to health promotion, individual development, and community cohesion (Aulenbacher et al., 2018; Brückner, 2010; England, 2005). In most Western societies, HEED occupations are female-dominated (Charles, 2011), with women comprising around 70% of the global health and social workforce, 74% in U.S. education and health services, and 77% in German health and social work (Bundesagentur für Arbeit, 2024; U.S. Bureau of Labor Statistics, 2023; World Health Organization, 2024). This concentration reflects associations of these occupations with stereotypically feminine attributes such as nurturing, warmth, empathy, and relationship orientation. Accordingly, male underrepresentation persists, often due to restrictive societal norms around masculinity, with men entering HEED domains potentially experiencing social penalties (Abele et al., 2016; Heilman & Wallen, 2010).

The acronym STEM collectively describes domains characterized by scientific inquiry, technological innovation, engineering problem-solving, and mathematical reasoning. These domains include diverse occupational roles, from research scientists (e.g., physicists, chemists) and engineers to computer science professionals, mathematicians, and specialized technicians (Fayer et al., 2017). Despite concerted efforts to increase women's participation, STEM remains male-dominated, with women constituting approximately 29% of the global workforce, 18% in the United States, and 17% in Germany (Bundesagentur für Arbeit, 2024; National Science Board & National Science Foundation, 2024; World Economic Forum, 2023). STEM occupations emphasize analytical thinking, independence, and problem-solving, attributes which align with stereotypically masculine attributes, contributing to perceptions of STEM domains as inherently masculine (Abele et al., 2016; Cheryan et al., 2009, 2017; Moss-Racusin et al., 2012; Nosek et al., 2009).

HEED and STEM domains represent extreme manifestations of occupational gender segregation, with stereotypical gender associations contributing to their persistence. Building on social role theory, ongoing observations of gendered occupational roles reinforce stereotypical perceptions of women's and men's suitability for HEED or STEM occupations, creating a self-perpetuating cycle where stereotypes both reflect and reproduce occupational gender patterns. These domains, therefore, serve as particularly revealing indicators of how gender stereotypes manifest in occupational contexts in a society.

Developmental Origins of Occupational Stereotypes: The Role of Textbooks

Occupational stereotype adoption begins early in life and solidifies during formative developmental periods such as preschool, primary school, and adolescence (Fagot et al., 2000; Koenig, 2018; Martin, 2000; Olsson & Martiny, 2018). During these critical stages, children and adolescents internalize societal beliefs about gender-appropriate roles, subsequently aligning their identities and interests with these internalized beliefs. Girls typically orient towards communal, care-oriented roles, while boys gravitate towards agentic, technical, or scientific roles (Klaczynski et al., 2020; Korlat et al., 2022; Su et al., 2009). This early internalization significantly impacts educational choices and eventual career pathways, making the sources of gender messages during these formative years particularly influential (Eccles, 2009, 2011; Wicht et al., 2022).

Textbooks serve as crucial socializing agents due to their daily, widespread use in classroom instruction. They not only shape pedagogical methods but also transmit social values and norms (Apple, 1987; Gräsel, 2010; Stará et al., 2017; Zala-Mezö et al., 2021). Through visual imagery, narratives, and linguistic choices, textbooks communicate both implicitly and explicitly occupational stereotypes and have the potential to reinforce gender-specific career aspirations and identities (Gottfredson, 2002; Höhne, 2005).

Prior research shows the influence of gendered representations on children's and adolescents' occupational aspirations, perceived self-efficacy, and scientific understanding and performance (Scott, 1986; Scott & Feldmann-Summers, 1979; Trepanier-Street & Romatowski, 1999; Witt, 2001). For instance, Good et al. (2010) found that girls showed better understanding and performance on chemistry tasks when learning materials included counter-stereotypical representations, such as female scientists, suggesting that representation impacts engagement and self-efficacy in specific domains. Similarly, experimental studies show that exposure to female STEM role models can positively influence

girls' self-concept and interest in STEM fields (Ziegler & Stoeger, 2008). Beyond visual representation, linguistic details also significantly influence perceptions of occupations (Stahlberg et al., 2007). The use of gender-neutral job titles encourage more inclusive understandings of occupational accessibility, an effect particularly pronounced in languages with grammatical gender, such as German (Liben et al., 2002; Vervecken et al., 2015).

School subjects are also associated with inherent gender stereotypes, influencing children's and adolescents' occupational perceptions indirectly (Kollmayer et al., 2017). Mathematics and sciences are stereotypically viewed as masculine, reinforcing their association with STEM careers, whereas language arts is perceived as more feminine, similar to HEED occupations. Research supports these associations. For example, Plante et al. (2009) found that students, regardless of gender, perceived language arts as strongly feminine and mathematics as relatively more masculine. These gendered perception of school subjects is closely tied to children's and adolescents' motivation, preferences, and ultimately, their educational and occupational trajectories (Kollmayer et al., 2018; Plante et al., 2009, 2019). Therefore, examining occupational representations within textbooks across subject-specific contexts, especially mathematics and language arts, provides critical insights into how gender stereotypes are perpetuated or challenged within educational systems.

In summary, textbooks are understood to play an important role in shaping children's and adolescents' occupational perceptions and aspirations. For this reason, analyzing their content through their visual, textual, and linguistic elements is crucial. Doing so provides valuable insight into the subtle mechanisms by which gendered occupational segregation is reproduced or challenged in educational settings.

Perspectives on Gender Representation in Occupational Roles in Textbooks

Research on gender representation in educational textbooks has undergone significant evolution since the 1960s, reflecting broader trends in feminist scholarship and sociocultural awareness (Mills & Mustapha, 2015; Moser, 2016). Initial studies focused on highlighting the substantial underrepresentation and, later, the stereotypical portrayal of women and girls. Over time, research methodologies have grown increasingly sophisticated, integrating linguistic and psychological frameworks to critically examine how textbooks reinforce gender stereotypes, particularly within occupational roles (Fichera, 1996; Hunze, 2003; Moser, 2016; Ott, 2021). Given the vast body of international research, this review concentrates on the literature most relevant to the present study's

design. We primarily draw from foundational and contemporary studies from German-speaking and Anglophone contexts. This focus is justified by the direct relevance of German-language research to our corpus and the influential role of early Anglophone studies in shaping the field's methodologies. Consequently, this review does not include the extensive body of research from other linguistic and cultural contexts (e.g., Scandinavia, Asia), as a comprehensive global overview is beyond the scope of this paper's specific focus. This review also includes some highly influential studies of related educational media (e.g., picture books, online resources) that have shaped theoretical and methodological approaches within textbook research. Furthermore, we prioritize studies that align with our research focus on specific school subjects (particularly language arts and mathematics), different school types (e.g., primary and secondary), and textbook types (e.g., reading books and subject-specific textbooks). Our review will first provide a chronological overview of general findings on occupational representation before focusing on the more specific literature on subject-specific differences.

Early textbook studies from the 1960s to the 1980s (Elbracht & Mosler, 1972; Ohlms, 1984; Sollwedel, 1968, 1971), inspired by second-wave feminism, primarily aimed to expose the invisibility and stereotypical portrayals of women, often using content analysis grounded in ideological critique (Apple, 1978; Bernstein, 1975). Influential Anglophone analyses, such as Weitzman et al.'s (1972) content analysis of 18 picture books for preschool children, highlighted severe imbalances, finding 261 pictures of men compared to only 23 of women, with a ratio of 11:1, and no instances of women in an occupational role. Similar patterns were reported for German textbooks: In a content analysis of 20 German elementary school reading books, Karsten (1976) found significant male dominance in character representation (71%) and occupational mentions (87%). Occupational mentions predominantly portrayed men in traditionally male domains (technical and production roles), with female roles restricted to service-oriented occupations. In a content analysis of 131 texts from three English language arts textbooks used in German secondary schools, Hellinger (1980) found that men were depicted across a broad spectrum of demanding careers, including car builders, bankers, engineers, scientists, and explorers. In contrast, women were confined to lower-status occupational roles such as waitress, office worker, nurse, maid, or housewife, with only two women in all three textbooks achieving high educational and professional status (as teacher and astronaut). Studies in this early period focused mainly on documenting baseline disparities in representation and the prevalence of traditional gender stereotypes.

In the 1990s, researchers began investigating whether earlier criticism of gender inequality in school textbooks (Clark

et al., 2005; Fichera, 1996; Preinsberger & Weisskircher, 1997; Witt, 1997) had prompted changes in gender portrayals, but found only minor improvements (Moser, 2016). For example, a study of Swiss textbooks by Bühlmann (2009) found in his content analysis of 203 texts in three textbooks of three publication cycles (1929, 1970, and 1990) that only 12% women were shown in an occupational role. While male characters were shown in a full range of professions, women were almost exclusively portrayed as farmers, saleswomen, cooks, or domestic servants. It was not until the 1990 textbook that teaching was added as a fifth occupation, and occupations like medicine, law, or skilled trades remained almost entirely male-dominated throughout the decades studied. In another key German study, Lindner and Lukesch (1994), in their content analysis of 72 German textbooks published between 1971 and 1992, covering German, mathematics, basic sciences, and religious education textbooks, also found persistent occupational gender segregation. Despite an increased general visibility of women (32% at the text level, 39% in pictures), women represented only 13% of textual occupational roles and 16% of pictorial occupational roles. The distribution of these roles was highly gendered. Of all occupations shown, 35% were in typically female domains (such as social care), and women were shown holding 62% of these typical female jobs. In contrast, 36% of the occupations were in typically male domains (such as academic positions), with women being shown in only 12% of these roles.

Research from 2000 to the present confirms the persistence of gender stereotypes, particularly concerning occupational portrayals, despite incremental improvements in the general visibility of women (Denny, 2011; Evans & Kimberly, 2000; Moser & Hannover, 2014; Ott, 2017b). A large-scale historical analysis of German textbooks by Ott (2017b) conducted a discourse-linguistic multilevel analysis of 88 German textbooks published between 1871 and 2014. While the study covers a vast historical period, her findings from the 2000s (2000–2013) are particularly revealing. In these modern textbooks, women's general mentions neared parity at around 42–43% of all personal references. However, a significant gap in occupational representation persisted, as a mention of a man was twice as likely to be in an occupational capacity (6% of all male mentions) than a mention of a woman (3% of all female mentions). In the U.S. context, Hamilton et al. (2006) conducted a content analysis of 200 popular children's picture books from the turn of the 21st century and found significant disparities in occupational representation. The analysis revealed that 75% of adult women were depicted without paid employment, compared to 51% of men. Additionally, men were portrayed in a substantially broader range of occupations (32 different jobs) versus women (12 jobs).

These occupational disparities reflected a broader pattern of gender under-representation, with male titles and main characters outnumbering females by nearly 2-to-1. Recent European studies confirm these findings. In their content analysis of nine current and widely used textbooks (five mathematics and four language arts textbooks) from five European countries, Jehle et al. (2024) found that female characters were significantly underrepresented in occupational contexts; only 22% of the characters with an occupation were female, and they appeared in fewer occupational categories than male characters (20 vs. 35). In a qualitative content analysis of illustrations in seven German geography textbooks from 2011 to 2020, Cruz Neri et al. (2024) found similar stereotypical patterns. In the category "Occupation and Activity," over 70% of illustrations depicted only or predominantly male figures.

There are only two recent studies examining gender representation in HEED and STEM, one focusing on online educational websites (Kerkhoven et al., 2016), the other on textbooks (Fruehwirth et al., 2024). Both reveal pronounced disparities. In a visual content analysis of 60 open-access science education resources (from the websites of Scientix and OERcommons; e.g., demonstrations, games, experiments) for the primary school level, Kerkhoven et al. (2016) identified significant male dominance in STEM roles (75%), alongside female dominance in teaching roles classified as non-STEM occupations. In a computer-aided quantitative text analysis of 202 current German language arts textbooks, Fruehwirth et al. (2024) employed a specific HEED and STEM categorization and reported male dominance not only in STEM occupations, where female representation was minimal, but also within the HEED domain, suggesting an overall portrayal of employment as a masculine sphere.

Studies comparing textbooks from different school subjects, while historically limited, have emerged more frequently in recent years, revealing nuanced differences in gender portrayals (Bittner, 2011; Jochim, 2014; Markom & Weinhäupl, 2007). This is especially the case for comparison between language and mathematics textbooks (Jehle et al., 2024; Ott, 2017b; van de Rozenberg et al., 2023). In their content analysis of 185 German textbooks, Lindner and Lukesch (1994) found that the proportional share of female characters in occupational roles was substantially higher in primary school German language arts textbooks (40.5%) than in mathematics textbooks (18.9%). However, this proportion declined sharply in textbooks for higher grade levels and more advanced school tracks. In a more recent German study, Moser and Hannover (2014) also found subject differences, with male characters being overrepresented in occupational roles across both subjects, but with men being described 1.8 times more frequently in occupational roles than women

in German language art textbooks and 2.1 times more frequently in mathematics textbooks. Furthermore, in both subject areas, men were portrayed with greater occupational diversity than women. Jehle et al. (2024) also found subject differences, with females only comprising 14% of occupational roles in mathematics textbooks compared to 25% in language arts textbooks.

Although textbook research has documented an increase in women's overall visibility since the 1960s, substantial gender disparities persist, particularly regarding occupational representation. Men remain significantly more likely to appear in a broader range of occupational contexts, particularly in STEM-related occupational roles. At the same time, women are typically depicted in traditionally feminine occupations. These differences seem even bigger in mathematics textbooks than in language arts textbooks.

However, significant thematic and methodological gaps remain in the literature. First, although earlier work has distinguished occupational roles by areas of activity (Hopfgartner, 1982; Silbermann & Krüger, 1971), existing analyses often lack a systematic focus on contemporary relevant domains like HEED and STEM (except Fruehwirth et al., 2024; Kerkhoven et al., 2016). Second, large-scale quantitative text analysis approaches have rarely been applied to examine gendered occupational portrayals, and if so, they were not applied across extensive time periods (Ott, 2017b). Third, comparative studies examining how these portrayals differ across specific school subjects that are gender connotated, notably language arts versus mathematics, are scarce (Lindner & Lukesch, 1994; Moser & Hannover, 2014; Ott, 2017b). The present study addresses these gaps through a large-scale, longitudinal, and comparative analysis of gender representation in the HEED and STEM domains employing quantitative corpus linguistic methods.

Current Study

To address the limitations identified in prior research, the present study investigates gender representations in a substantial corpus of 820 German language arts and mathematics textbooks spanning from 1960 to 2017, specifically analyzing diachronic trends within the HEED and STEM domains and assessing subject-specific variations. Our primary goals were to quantitatively assess how the proportional representation of women relative to men in HEED and STEM domains has evolved over time and whether these temporal patterns differ significantly between German language arts and mathematics textbooks, potentially reflecting subject-specific gender stereotypes. We also examined parallel trends in the normalized frequencies (mentions per 1000 words) of female and male terms to understand changes in absolute rates of mention.

Based on findings on occupational gender segregation (Froehlich et al., 2020; Hsu et al., 2021; Weisgram et al., 2011), we developed six hypotheses to examine how these societal patterns manifest in textbooks. Our first hypothesis tests whether textbooks reflect occupational gender-domain associations:

Hypothesis 1. The frequency of female mentions in STEM occupations in textbooks is significantly lower than the frequency of female mentions in HEED occupations.

Based on documented societal shifts toward increased female labor force participation (Blau et al., 2014), changing gender roles (Eagly et al., 2020), and textbook research, indicating slow increases in female representation (Moser, 2016; Ott, 2021), our second set of hypotheses addresses temporal trends. We first posited a general, linear increase in female representation over the entire period:

Hypothesis 2a: The frequency of female mentions in occupational roles (independent of the occupational domain) has significantly increased over the period 1960–2017.

In addition to this general trend, we sought to more precisely test the impact of the 1986 governmental resolution on gender equity in textbooks (KMK, 1986). Therefore, we also hypothesized a clear discontinuity in representation corresponding to this date:

Hypothesis 2b: There is a jump in the female mentions in occupational roles across subjects and domains in textbooks published after the governmental resolution on gender equity in 1986.

However, given the persistent gender gaps in STEM occupational domains compared to the gradual progress in other domains (England et al., 2020; Fayer et al., 2017; World Economic Forum, 2023), we anticipated that temporal trends would differ significantly between HEED and STEM. Therefore, in our third hypothesis, we tested the interaction between domain and time:

Hypothesis 3. The frequency of female mentions in STEM occupational roles has increased less than the frequency of female mentions in HEED occupational roles between 1960 and 2017.

Based on findings that school subjects show gender connotations (i.e., mathematics being a stereotypical masculine subject and language arts being a typical feminine subject)

(Chaffee & Plante, 2021; Plante et al., 2009) and that the temporal differences in gender occupational representation are more persistent in mathematics textbooks than in language arts textbooks (Moser & Hannover, 2014), we hypothesized subject-specific differences:

Hypothesis 4. The frequency of female mentions in occupational roles (independent of occupational domain) in mathematics textbooks has increased less than in German language arts textbooks between 1960 and 2017.

Finally, based on the differences concerning occupational gender representations in subject areas and occupational domains over time, we also hypothesized a three-way interaction:

Hypothesis 5: The increase in the frequency of female mentions over time is most pronounced in German language arts textbooks for HEED occupations and least pronounced in mathematics textbooks for STEM occupations.

Method

Sample

We created the textbook corpus as part of the project *Gender & Care in the Media* within the Bavarian research

association *ForGenderCare* and funded by Bavarian State Ministry of Science and the Arts.

The original corpus included over 2,000 German language arts, mathematics, English, and science textbooks. For the present study, we analyzed a sub-corpus of 820 textbooks from primary schools (*Grundschule*), secondary schools (intermediate track) (*Mittelschule* and *Realschule*), and secondary schools (academic track) (*Gymnasium*) in the subjects of German language arts ($n = 523$) and mathematics ($n = 297$). This specific selection was made to directly compare a subject stereotyped as feminine (language arts) with one stereotyped as masculine (mathematics), a core objective of our research design. Table 1 provides a detailed overview of the textbook corpus, including information on school type, time of publication, number of textbooks, and word counts.

Textbook Selection

We included all textbooks that were approved as learning resources by the Bavarian State Ministry of Education and Cultural Affairs for use in Bavarian schools between 1960 and 2017. Textbooks published after 1986 were subject to the resolution on gender-equitable representation in textbooks. The distribution of textbooks published in different periods varies due to production processes and curriculum connections. There is a gap in the textbook corpus between 1997 and 2000 due to the introduction of the new Bavarian curriculum,

Table 1 Textbook Corpus: German Language Arts and Mathematics by School Type and Time (1960–2017)

School type	1960–1975	1976–1985	1986–1995	1996–2005	2006–2017
German Language Arts					
Primary school	52	28	17	9	56
Secondary school (intermediate track)	80	7	30	46	49
Secondary school (academic track)	51	21	7	13	40
no specification	10	7	0	0	0
Total (Books)	193	63	54	68	145
Total (Word count)	12,137,611	2,632,590	2,763,139	3,880,878	8,413,958
Mathematics					
Primary school	9	14	3	0	60
Secondary school (intermediate track)	16	18	9	22	49
Secondary school (academic track)	22	16	16	9	28
no specification	6	0	0	0	0
Total (Books)	53	48	28	31	137
Total (Word count)	1,673,849	1,378,688	997,272	1,241,815	3,819,234

Note. Textbooks without specified school types, or with types lacking modern equivalents, are labeled “no specification”. To maintain consistency despite changes in the German school system, textbooks were reclassified by school type: those from intermediate-level schools (*Mittelschule*, *Realschule*) were combined into “secondary schools (intermediate track)”; those from primary and lower secondary schools (*Volksschule*, *Hauptschule*) were categorized as either “primary school” or “secondary school (intermediate track)” based on grade levels; and those from college-preparatory schools (*höhere Lehranstalt*) became “secondary school (academic track)”. Word counts represent the sum of words across all textbooks in each category

as textbook publishers typically delay the release of new editions until new curricula are finalized and implemented.

Corpus Composition

The corpus spans the period from 1960 to 2017 and for descriptive analysis it was divided into five intervals: 1960–1975, 1976–1985, 1986–1995, 1996–2005, and 2006–2017. All textbooks in the corpus were digitized using the OCR software ABBYY Fine Reader 16 and converted into text files using UTF-8 encoding. A script was used to convert gender-fair abbreviations of occupational terms used in the German language (e.g., *Lehrer/-in* [female and male teacher]) into feminine-masculine word pairs (e.g., *Lehrerin und Lehrer* [female teacher and male teacher]).

Procedure

Data Collection

To collect the data, we used the word lists of terms for HEED and STEM occupations developed by Fruehwirth et al. (2024). The word lists are based on the official occupational classification of the German Federal Employment Agency (Bundesagentur für Arbeit, 2011) and capture the full range of HEED and STEM occupation domains. The word list for HEED 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]). The word list for STEM occupations contained 286 male terms (e.g., *Physiker* [male physicist], *Chemiker* [male chemist]) and 286 female terms (e.g., *Physikerin* [female physicist], *Chemikerin* [female chemist]).

Our analysis was based on a token-based approach, counting each occurrence of a term from these lists. We analyzed only the running text of the textbooks; text within illustrations was not included. The analysis focused on these grammatically gendered nouns and did not capture occupational activity described in sentence-like expressions (e.g., “she works in a drugstore”). Following this logic, potentially generic masculine forms were counted as male, and gender-neutral terms (e.g., *Feuerwehrdienstleistende* [fire fighters]) were not included in our analysis.

Our reliance on these binary word lists necessitates a binary operationalization of gender. This approach is necessitated by the specific word lists employed for data collection, which are derived from official binary occupational categories. Furthermore, it aligns with the theoretical conceptualization of gender as a structural category in occupational segregation research (Aulenbacher, 2008; Jarman et al., 2012; Wong & Charles, 2020). A more detailed discussion of this binary focus and its limitations with respect

to contemporary understandings of gender (Schmader & Nater, 2025) is provided in the discussion.

We used the word-counting functionality of the text analysis program *LIWC-22* (Boyd et al., 2022) to calculate the frequency of matching terms in the corpus. Each token was lemmatized to its nominative singular form before counting. The results were exported to an Excel file and subsequently integrated into SPSS and R (R Core Team, 2024) for further statistical analysis.

Data Analysis

Descriptive Analysis We conducted descriptive analyses using SPSS version 29. This included calculating the absolute frequencies (*n*), means (*M*), and standard deviations (*SD*) of the male and female HEED and STEM occupations per textbook. To account for differences in textbook length, we normalized frequencies per 1000 words and calculated the proportional share of the female mentions relative to total mentions. To complement these aggregated metrics, we also identified the most frequent specific occupational titles. These descriptive statistics were calculated for the combined sample of German language arts and mathematics textbooks, which we refer to as the ‘combined’ sample, as well as the sample of German language arts and mathematics textbooks separately. For temporal comparison, we divided the data into the five intervals: 1960–1975, 1976–1985, 1986–1995, 1996–2005, and 2006–2017. The rationale behind these splits is based on both methodological and theoretical considerations. First, this division allowed for a more balanced distribution of textbooks across periods, which helped prevent data skew and proved beneficial for subsequent model fitting. Second, in 1986, the German Standing Conference of the Ministers of Education and Cultural Affairs passed a resolution stating that genders should be represented equally in German school textbooks (KMK, 1986). Accordingly, we sought to distinguish between textbooks published before and after the resolution to assess its potential impact.

Inferential Analysis To test the study’s hypotheses and explore changes over time and differences related to occupational domain (HEED vs. STEM) and textbook subject (German language arts vs. mathematics), we employed an interrupted time series analysis using generalized linear mixed effects models (GLMMs) in R (version 4.4.2; R Core Team, 2024). Interrupted time-series analyses have proven highly useful for contrasting temporal changes before and after a specific point in time, e.g., a medical intervention, as such models technically allow for changes in intercepts and/or slopes after that point (Hategeka et al., 2020). The passage of a normative resolution marks a crucial point in time after which we would expect changes in both the intercept and the slope. GLMMs have been increasingly used in corpus-linguistic research (Tagliamonte & Baayen, 2012), which is concerned with observational and

Table 3 Descriptive Statistics of Female and Male HEED and STEM Occupations by Subject and Time (1960–2017)

Time	N	HEED				STEM											
		Female				Male				Female				Male			
		n	M	SD	1000W	n	M	SD	1000W	n	M	SD	1000W	n	M	SD	1000W
German Language Arts																	
1960–1975	193	846	4.38	5.44	0.070	6015	31.17	29.58	0.496	4	0.02	0.14	0.000	771	3.99	6.73	0.064
1976–1985	63	239	3.79	5.48	0.091	1416	22.48	19.09	0.538	3	0.05	0.38	0.001	148	2.35	3.98	0.056
1986–1995	54	360	6.67	6.20	0.130	1780	32.96	22.86	0.644	8	0.15	0.74	0.003	115	2.13	5.07	0.042
1996–2005	68	697	10.25	9.14	0.180	2477	36.43	23.44	0.638	9	0.13	0.42	0.002	155	2.28	3.90	0.040
2006–2017	145	1465	10.10	11.60	0.174	4835	33.34	28.36	0.575	79	0.54	2.12	0.009	496	3.42	6.63	0.059
1960–2017	523	3607	6.90	8.60	0.121	16523	31.59	26.92	0.554	103	0.20	1.18	0.003	1685	3.22	5.99	0.057
Mathematics																	
1960–1975	53	12	0.23	0.72	0.007	147	2.77	2.46	0.088	1	0.02	0.14	0.001	116	2.19	4.16	0.069
1976–1985	48	15	0.31	0.78	0.011	90	1.88	1.94	0.065	2	0.04	0.20	0.001	279	5.81	10.39	0.202
1986–1995	28	7	0.25	0.65	0.007	152	5.43	12.39	0.152	0	0.00	0.00	0.000	165	5.89	9.03	0.165
1996–2005	31	33	1.06	0.93	0.027	155	5.00	11.77	0.125	2	0.06	0.25	0.002	132	4.26	8.84	0.106
2006–2017	137	107	0.78	1.08	0.028	415	3.03	3.29	0.109	2	0.01	0.12	0.001	363	2.65	4.21	0.095
1960–2017	297	174	0.59	0.97	0.019	959	3.23	5.98	0.105	7	0.02	0.15	0.001	1055	3.55	6.77	0.116

Note. N = Number of textbooks. n = total raw count of mentions; M = mean number of mentions per textbook; SD = standard deviation of mentions per textbook. $HEED$ = health care, early education, and domestic work. $STEM$ = science, technology, engineering, and mathematics. $1000W$ = Number of mentioned occupations per 1000 words of text

Descriptive Overview

Overall trends in the total frequency of occupational mentions, irrespective of gender, are presented in the Appendix in Tables 4, 5, 6. This data provides context for our main analysis and shows that the normalized frequency of total HEED mentions fluctuated but ended slightly higher at the end of the study period (from 0.508 to 0.558 per 1000 words), while total STEM mentions remained considerably lower and relatively stable (from 0.065 to 0.077 per 1000 words) (Table 4).

Furthermore, German language arts textbooks (Table 5) contained a higher overall frequency of occupational mentions, particularly within HEED, compared to mathematics textbooks (Table 6), which, despite lower overall frequencies, showed a proportionally higher emphasis on STEM mentions in some periods.

Regarding specific occupational titles, within HEED domain, the teaching profession played a central role for both genders; the term *Lehrerin* [female teacher] became increasingly prominent over time (total $n = 2,201$), while *Lehrer* [male teacher] was one of the most frequent male terms (total $n = 11,081$). In the STEM domain, male

Table 4 Total Occupational Mentions (HEED and STEM) Across Time (1960–2017): Combined Sample

Time	Number of textbooks	n	M	SD	1000W
Combined (HEED + STEM)					
1960–1975	246	7912	32.16	36.06	0.573
1976–1985	111	2192	19.75	22.57	0.546
1986–1995	82	2587	31.55	30.58	0.688
1996–2005	99	3660	36.97	34.79	0.714
2006–2017	282	7762	27.52	37.54	0.635
1960–2017	820	24113	29.41	34.67	0.619
HEED					
1960–1975	246	7020	28.54	32.35	0.508
1976–1985	111	1760	15.86	21.19	0.439
1986–1995	82	2299	28.04	28.55	0.611
1996–2005	99	3362	33.96	32.48	0.656
2006–2017	282	6822	24.19	33.78	0.558
1960–2017	820	21263	25.93	31.57	0.546
STEM					
1960–1975	246	892	3.63	6.34	0.065
1976–1985	111	432	3.89	7.64	0.108
1986–1995	82	288	3.51	6.94	0.077
1996–2005	99	298	3.01	6.02	0.058
2006–2017	282	940	3.33	6.36	0.077
1960–2017	820	2850	3.48	6.55	0.073

Note. Shows total occupational mentions regardless of gender for combined sample (German language arts and mathematics textbooks). n = total raw count of mentions; M = mean number of mentions per textbook; SD = standard deviation of mentions per textbook. HEED = health care, early education, and domestic work. STEM = science, technology, engineering, and mathematics. 1000W = Number of mentioned occupations per 1000 words of text

Table 5 Total Occupational Mentions (HEED and STEM) Across Time (1960–2017): German Language Arts Textbooks

Time	Number of textbooks	<i>n</i>	<i>M</i>	<i>SD</i>	1000W
Combined (HEED + STEM)					
1960–1975	193	7636	39.56	37.35	0.629
1976–1985	63	1806	28.67	25.05	0.686
1986–1995	54	2263	41.91	30.21	0.819
1996–2005	68	3338	49.09	33.76	0.860
2006–2017	145	6875	47.41	43.43	0.817
1960–2017	523	21918	41.91	37.22	0.735
HEED					
1960–1975	193	6861	35.55	33.23	0.565
1976–1985	63	1655	26.27	23.17	0.629
1986–1995	54	2140	39.63	27.64	0.774
1996–2005	68	3174	46.68	30.91	0.818
2006–2017	145	6300	43.45	37.99	0.749
1960–2017	523	20130	38.49	33.24	0.675
STEM					
1960–1975	193	775	4.02	6.78	0.064
1976–1985	63	151	2.40	4.03	0.057
1986–1995	54	123	2.28	5.25	0.045
1996–2005	68	164	2.41	4.02	0.042
2006–2017	145	575	3.97	7.82	0.068
1960–2017	523	1788	3.42	6.42	0.060

Note. Shows total occupational mentions regardless of gender for German language arts textbooks only. *n* = total raw count of mentions; *M* = mean number of mentions per textbook; *SD* = standard deviation of mentions per textbook. HEED = health care, early education, and domestic work. STEM = science, technology, engineering, and mathematics. 1000W = Number of mentioned occupations per 1000 words of text

representation was typified by subject-specific roles such as *Ingenieur* [male engineer; total *n* = 711] and *Physiker* [male physicist; total *n* = 479] in German language arts textbooks, and *Mathematiker* [male mathematician; total *n* = 719] in mathematics textbooks. In contrast, female STEM titles were marginal; for instance, *Ingenieurin* [female engineer] appeared only 22 times in total across six decades.

Inferential Analysis of Gender Occupational Representation

To formally test our hypotheses, we fitted a binomial generalized linear mixed-effects model. The random effect standard deviation for TEXTBOOK ID was 0.55, indicating substantial variation between individual textbooks. All model assumptions were met. Detailed model coefficients are presented in Table 7 and full descriptive statistics, including raw counts (*n*), means (*M*), standard deviations (*SD*), and normalized frequencies (1000W), were previously shown in Tables 2 and 3. In the following sections, each hypothesis is presented as a subheading. For each, we first report the result of the omnibus test (i.e., the χ^2 value), followed by supporting evidence from

Table 6 Total Occupational Mentions (HEED and STEM) Across Time (1960–2017): Mathematics Textbooks

Time	Number of textbooks	<i>n</i>	<i>M</i>	<i>SD</i>	1000W
Combined (HEED + STEM)					
1960–1975	53	276	5.21	5.60	0.165
1976–1985	48	386	8.04	10.84	0.280
1986–1995	28	324	11.57	19.66	0.325
1996–2005	31	322	10.39	18.58	0.259
2006–2017	137	887	6.47	6.79	0.232
1960–2017	297	2195	7.39	10.93	0.241
HEED					
1960–1975	53	159	3.00	2.78	0.095
1976–1985	48	105	2.19	2.44	0.076
1986–1995	28	159	5.68	12.58	0.159
1996–2005	31	188	6.06	11.90	0.151
2006–2017	137	522	3.81	3.90	0.137
1960–2017	297	1133	3.81	6.28	0.124
STEM					
1960–1975	53	117	2.21	4.18	0.070
1976–1985	48	281	5.85	10.40	0.204
1986–1995	28	165	5.89	9.03	0.165
1996–2005	31	134	4.32	8.92	0.108
2006–2017	137	365	2.66	4.24	0.096
1960–2017	297	1062	3.58	6.79	0.117

Note. Shows total occupational mentions regardless of gender for mathematics textbooks only. *n* = total raw count of mentions; *M* = mean number of mentions per textbook; *SD* = standard deviation of mentions per textbook. HEED = health care, early education, and domestic work. STEM = science, technology, engineering, and mathematics. 1000W = Number of mentioned occupations per 1000 words of text

Table 7 Binomial GLMM Estimates (Log-Odds) for Gender of Occupational Terms

Predictor	<i>B</i>	<i>SE</i>	<i>z</i>	<i>p</i>
(Intercept)	−1.82	0.08	−21.50	<.001***
Time	0.02	0.01	3.91	<.001***
Post	0.16	0.16	1.03	.304
Domain				
STEM (ref = HEED)	−2.79	0.40	−6.92	<.001***
Subject				
Mathematic	0.38	0.30	1.28	.202
Time × Domain STEM	0.04	0.02	2.48	<.013*
Time × Subject Mathematics	0.06	0.01	4.14	<.001***
Post × Domain STEM	1.11	0.63	1.76	.079
Post × Subject Mathematics	−1.98	0.58	−3.42	<.001***
Time × Subject Mathematics × Domain STEM	−0.10	0.02	−5.24	<.001***

Note. β = log-odds; *SE* = standard error. The outcome variable is Gender, with “male” as the reference category; positive β values indicate higher odds of a term being “female.” Random effect *SD* (ID) = 0.55. AIC = 19917.9; BIC = 20007

p* < .05. *p* < .01. ****p* < .001

the descriptive proportional shares (Table 8) and specific post-hoc pairwise comparisons (Odds Ratios).

Table 8 Descriptive Proportion (%) of Female Occupational Mentions by Domain Subject, and Time (1960–2017)

Time	Overall HEED (%)	Overall STEM (%)	German language arts HEED (%)	German language arts STEM (%)	Math HEED (%)	Math STEM (%)
1960–1975	12.2	0.0	12.4	0.0	7.4	1.4
1976–1985	14.4	0.9	14.5	1.8	14.4	0.5
1986–1995	16.0	2.6	16.8	6.7	4.4	0.0
1996–2005	21.8	3.5	22.0	4.8	17.8	1.9
2006–2017	23.1	9.1	23.2	13.3	20.5	1.0
1960–2017	17.8	3.9	17.9	5.8	16.4	0.7

Note. Values represent the percentage of female occupational mentions relative to total mentions (female + male) within each category, calculated from normalized frequencies per 1000 words. HEED = health care, early education, and domestic work. STEM = science, technology, engineering, and mathematics

Hypothesis 1: Frequency of Female Mentions in STEM Occupations in Textbooks is Significantly Lower Than the Frequency of Female Mentions in HEED Occupations

Confirming our first hypothesis, female mentions were significantly less frequent in STEM occupations than in HEED occupations, $\chi^2(1) = 47.92$, $p < .001$. The descriptive data,

summarized in Table 8 (proportional shares) and visualized in Figure 1 (proportional shares) and Figure 2 (normalized frequencies), illustrate this disparity. Overall, the proportional share of female mentions in HEED was 17.8%, compared to just 3.9% in STEM. The odds of an occupational mention being female were approximately nine times higher in the HEED domain than in the STEM domain ($OR = 9.78$, $p < .001$).

Figure 1 Share of Female Mentions (%) in HEED and STEM Occupations by Subject and Time (1960–2017). *Note.* Points represent the descriptive proportional share of female mentions relative to total mentions within each time period, subject, and domain. The ‘combined’ panel displays data aggregated across both German language arts and mathematics textbooks. HEED = health care, early education, and domestic work. STEM = science, technology, engineering, and mathematics

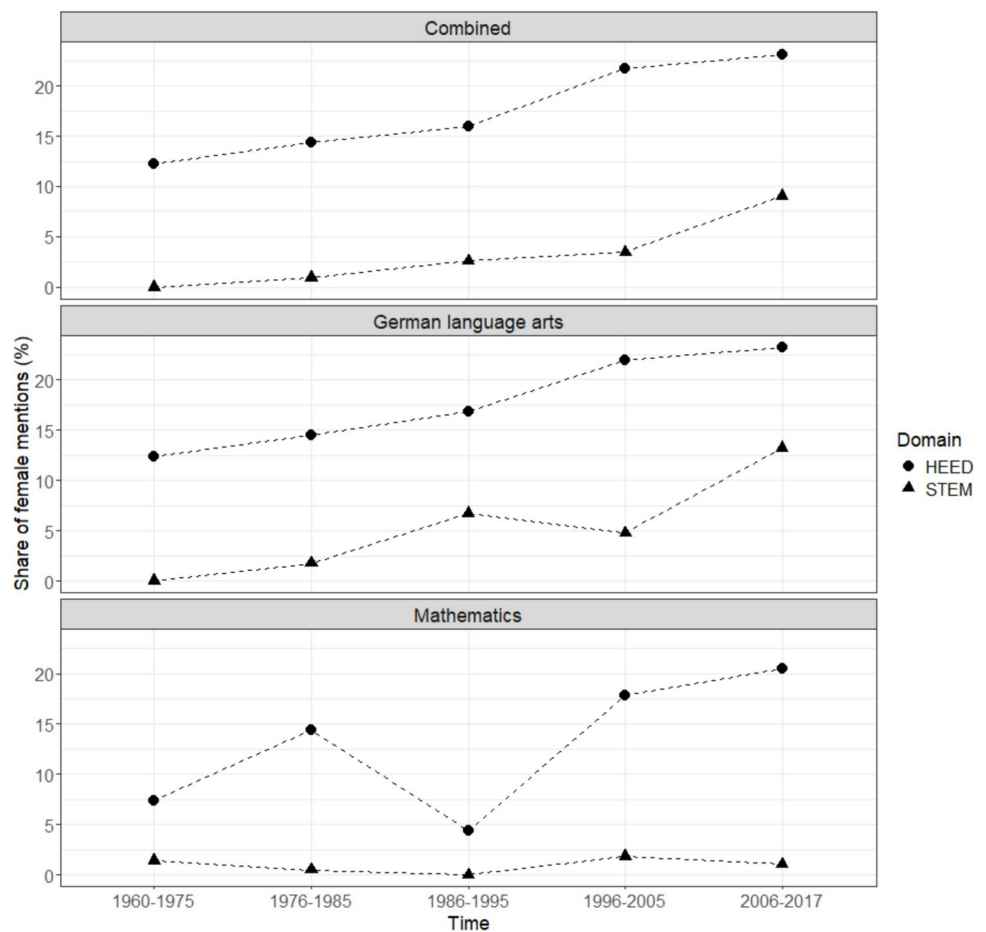
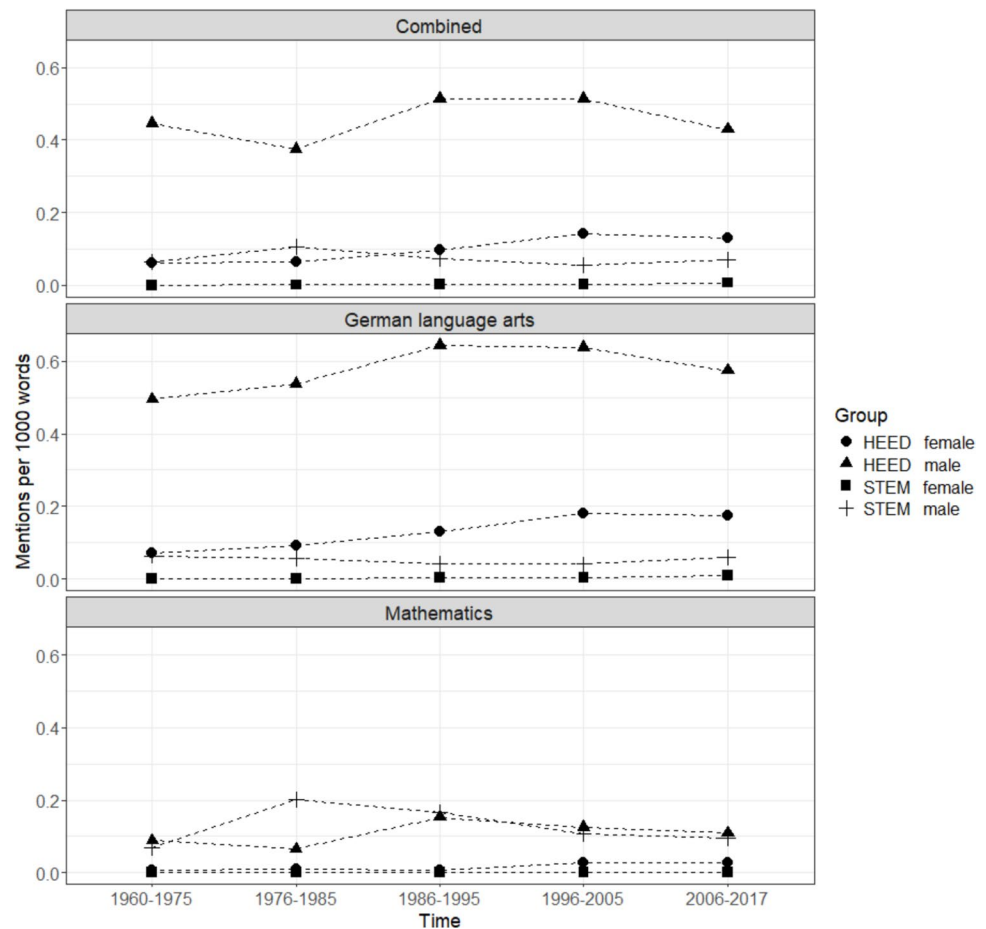


Figure 2 Rate of Male and Female Mentions in HEED and STEM Occupations by Subject and Time (1960–2017). *Note.* Rates shown as mentions per 1000 words. The ‘combined’ panel displays data aggregated across both German language arts and mathematics textbooks. HEED = health care, early education, and domestic work. STEM = science, technology, engineering, and mathematics



Hypothesis 2a: The Frequency of Female Mentions in Occupational Roles (Independent of the Occupational Domain) has Significantly Increased over the Period 1960–2017

In line with our second hypothesis, the frequency of female mentions increased significantly over the study period, $\chi^2(1) = 15.32, p < .001$. The descriptive data show that the combined proportional share of female mentions across all domains and subjects rose from 11.4% in 1960–1975 to 21.3% in 2006–2017 (Table 8). The time trend was significant, with the odds of a female mention increasing by 4% per year (est = 0.04, $p < .001$). Visual inspection of the descriptive data (Figures 1 and 2) suggests the increase may have been more pronounced from the mid-1990s onward.

Hypothesis 2b: There is a Jump in the Female Mentions in Occupational Roles across Subjects and Domains in Textbooks Published after the Governmental Resolution on Gender Equity in 1986

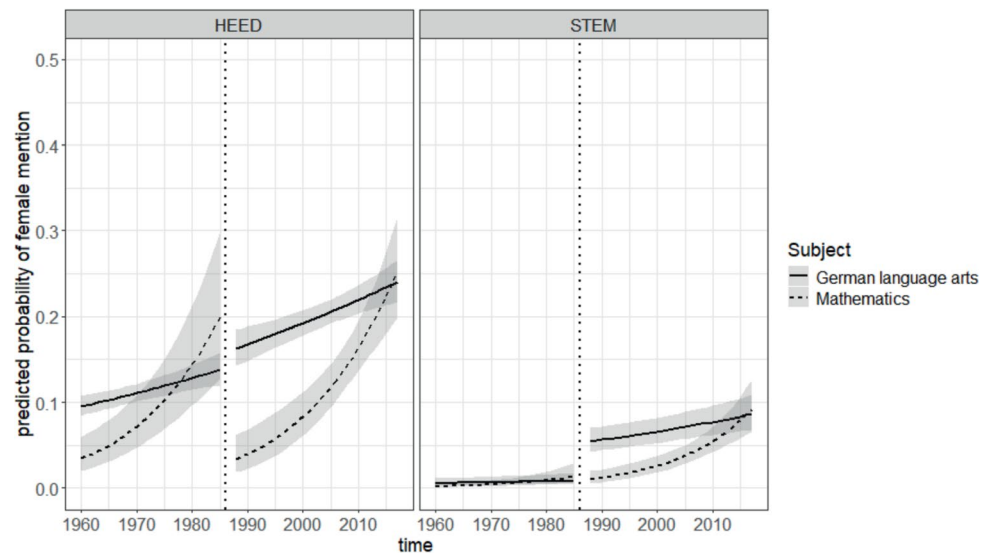
Overall, we do not find a significant main effect of the factor POST, $\chi^2(1) = 1.05, p = .304$, but the factor interacted

significantly with SUBJECT, $\chi^2(1) = 11.71, p < .001$. In German language arts books, the odds for female mentions doubled after 1986 (OR = 2.04, $p < .038$), whereas in mathematics textbooks, female mentions decreased substantially, being 3.5 times higher before 1986 than after (OR = 0.28, $p < .031$). These differences are illustrated in Figure 3, which shows a positive jump for German language arts textbooks across domains in 1986, and a noticeable drop in mathematics textbooks, especially in the HEED domain.

Hypothesis 3: The Frequency of Female Mentions in STEM Occupational Roles has Increased Less Than the Frequency of Female Mentions in HEED Occupational Roles Between 1960 and 2017

The model revealed a significant TIME $\times$ DOMAIN interaction, $\chi^2(1) = 6.12, p < .013$, indicating that temporal trends differed between HEED and STEM domains. The descriptive data (Table 8) show that the proportional share of female mentions increased from 12.2% to 23.1% in HEED and from 0.0% to 9.1% in STEM. However, post-hoc comparisons

Figure 3 Predicted Probability of Female Occupational Terms by Domain and Subject Across Time (1960–2017). Note. Lines show predicted probabilities from an interrupted time-series analysis based on a binomial GLMM; error bands show 95% confidence intervals; the vertical dotted line represents 1986. HEED = health care, early education, and domestic work. STEM = science, technology, engineering, and mathematics



of the temporal slopes between HEED and STEM were non-significant when averaged across subjects ($\text{est} = 0.01$, $p = .427$). This apparent discrepancy arises because TIME and DOMAIN are involved in a three-way interaction with SUBJECT, meaning that the domain-specific trends differ between German language arts and mathematics textbooks (see Hypothesis 5).

Hypothesis 4: The Frequency of Female Mentions in Occupational Roles in Mathematics Textbooks Increased Less Than in German Language Arts Textbooks Between 1960 and 2017

As hypothesized, the increase in female representation in occupational roles was significantly less pronounced in mathematics than in German language arts textbooks, which is supported by a significant TIME $\times$ SUBJECT interaction, $\chi^2(1) = 17.10$, $p < .001$, and by a significant POST $\times$ SUBJECT interaction, $\chi^2(1) = 11.71$, $p < .001$. The model's predictions (Figure 3) show that this subject-specific divergence intensified over time, particularly driven by differing trends within the STEM domain. The descriptive data show that the proportional share of female STEM mentions in German language arts textbooks rose from 0.0% to 13.3%, while in mathematics textbooks it remained at a consistently low level (1.4% to 1.0%) throughout the study period (Table 8). Post-hoc tests confirmed that no significant differences existed between the two subjects before 1986 ($\text{OR} = 0.67$, $p = .225$), but a substantial gap emerged after the passage of the 1986 resolution, with the odds of an occupational mention being female were almost 5 times higher in German language arts than in mathematics textbooks ($\text{OR} = 4.81$, $p < .001$).

Hypotheses 5: The Increase in the Frequency of Female Mentions Over Time is Most Pronounced in German Language Arts Textbooks for HEED Occupations and Least Pronounced in Mathematics Textbooks for STEM Occupations

Our analysis revealed a significant three-way interaction of TIME $\times$ SUBJECT $\times$ DOMAIN, $\chi^2(1) = 27.42$, $p < .001$, which uncovered a complex pattern. For German language arts textbooks, female mentions were 14 times more likely in the HEED domain than in the STEM domain before 1986 ($\text{OR} = 14.12$, $p < .001$), and 4.6 times more likely after 1986 ($\text{OR} = 4.65$, $p < .001$). For mathematics textbooks, female mentions were nearly 21 times more likely in the HEED domain than in the STEM domain before 1986 ($\text{OR} = 20.58$, $p < .001$), and almost 7 times more likely after 1986 ($\text{OR} = 6.78$, $p < .001$). This pattern indicates that the HEED-STEM gap narrowed over time in both subjects, suggesting a steeper increase in female STEM representation than in HEED. This runs counter to our initial hypothesis, although the absolute levels of female STEM representation remained very low throughout the study period.

Discussion

This study provided the first comprehensive longitudinal analysis of gender representation in HEED and STEM occupations across 820 German language arts and mathematics textbooks spanning nearly six decades (1960–2017). Our findings reveal persistent gender occupational segregation: women remain underrepresented in occupational

roles, especially in STEM occupations, compared to HEED occupations throughout the study period. This was particularly evident in mathematics textbooks, where virtually no change occurred in the representation of females in STEM domains. Furthermore, the 1986 governmental resolution on gender equity had divergent effects across subjects: while female representation saw a sharp spike in German language arts textbooks, it underwent a sudden plunge in mathematics textbooks.

Underrepresentation of Women in Occupational Roles

Our analysis revealed that women are mentioned significantly less in STEM occupations than in HEED occupations across the whole study period (H1). This finding aligns with previous evidence from textbook research documenting severe underrepresentation of women in STEM occupations (Fruehwirth et al., 2024; Kerkhoven et al., 2016) and technical occupations (Cruz Neri et al., 2024; Finsterwald & Ziegler, 2007; Ott, 2017b). Furthermore, beyond this domain-specific disparity, our data also reveal that women are systematically underrepresented across all domains compared to men. Overall, female mentions comprised only 3.9% in STEM and even in HEED occupations, traditionally a feminine work sphere, women comprised only 17.8% of mentions overall, reaching just 23.1% by 2006–2017. It is especially concerning that female underrepresentation was found throughout our study period of nearly six decades. This indicates that even current textbooks primarily construct paid work as masculine, with women's labor participation rendered largely invisible.

The systematic underrepresentation of women may constrain children's and adolescents' ability to envision gender-diverse HEED and STEM careers. Research confirms that counter-stereotypical representations can positively influence girls' STEM engagement and performance (Good et al., 2010), while the absence of female role models leads to perceptions that STEM is a male occupational domain (Lindner & Makarova, 2024). Other research indicates similar effects for HEED occupations, where the absence of male role models constrains boys' engagement in health, education, and care fields (Puzio & Valshtein, 2022). Through daily classroom use, textbooks communicate implicit messages about occupational gender-appropriateness, potentially crystallizing beliefs about who belongs in HEED and STEM domains throughout students' educational careers (Curd-Christiansen, 2017; Eagly & Wood, 2012; Watt & Eccles, 2008). In terms of future research, it would be useful to examine long-term effects of textbook exposure (Behnke, 2018) on HEED and STEM career aspirations.

Differential Temporal Development Across HEED and STEM Domains

Our findings confirm that female occupational representation increased significantly over the study period (H2a), yet this development proved highly uneven across the two occupational domains (H3). While the proportional share of female mentions increased in both domains, the nature of this change differed substantially. In HEED occupations, female representation showed a consistent, substantial increase in proportional share, increasing from 12.2% to 23.1%. In STEM, the increase was from a starting point of zero, making the relative fold-increase appear large, but the absolute endpoint of 9.1% remained low, falling short of the level HEED had already achieved in the 1960s. This indicates that while both domains saw change, the progress in STEM was not sufficient to meaningfully alter its status as a male-dominated field within the textbook landscape.

This finding contributes a critical longitudinal dimension to existing textbook research. Whereas past studies have often categorized occupations into broad “typically female/male” domains (Finsterwald & Ziegler, 2007; Lindner & Lukesch, 1994; Ott, 2017b), our study provides the first direct demonstration of the differential pace of change specifically within the contemporary occupational domains of HEED and STEM. The results suggest that these domains operate as self-reinforcing systems within educational media. Culturally feminized work (Puzio & Valshtein, 2022), such as the HEED domain, proved more permeable to increases in female representation over time. This may be because including more women in domains already conceptualized as “appropriate” for them—and often societally devalued—does not fundamentally challenge existing gender schemas or status hierarchies (Bern, 1981; Starr & Zurbriggen, 2017). In contrast, the slower absolute progress in STEM suggests its strong masculine associations created greater cultural resistance to change. This indicates that the patriarchal and hierarchical gender order, where masculinity is positioned as superior to femininity (e.g., Connell, 1987; Risman, 2004, as cited in Puzio & Valshtein, 2022), remains a powerful and persistent element within textbooks. This is a notable finding, as it suggests that the content of educational media stays static and may not fully reflect the dynamic and evolving nature of gender stereotypes that have been documented in broader society (Dickman & Eagly, 2000; Eagly et al., 2020).

Subject-Specific Differences: Mathematics Versus Language Arts

A particularly notable finding of this study was the significant divergence in gender representation between German

language arts and mathematics textbooks over time (H4). While both subjects began with similarly low levels of female representation in the 1960s, their developmental paths diverged significantly. Our discontinuity analysis pinpoints the 1986 governmental resolution on gender equity (KMK, 1986) as the critical juncture for this divergence (H2b). Rather than a uniform effect, the results revealed that the resolution's impact was subject-specific: in German language arts textbooks, female representation showed a positive jump immediately after 1986, whereas in mathematics textbooks, the probability of female mentions dropped immediately after 1986, though the general upward trend continued over time. Consequently, while no significant differences existed between the two subjects before 1986, a substantial gap emerged thereafter. By the final period (2006–2017), the odds of an occupational mention being female were almost five times higher in German language arts than in mathematics textbooks. This finding does not simply confirm that mathematics textbooks are more gender-stereotypical (Jehle et al., 2024; Moser & Hannover, 2014). Our longitudinal data demonstrate that subject-specific gender disparities in occupational representation have intensified over the last six decades: while German language arts textbooks showed substantial progress towards greater gender equity, mathematics textbooks showed only minimal change.

One interpretation is that textbooks act as key mechanisms within larger, self-reinforcing cycles of educational gender stereotyping (Kollmayer et al., 2017). School subjects themselves are culturally coded: mathematics is associated with masculine-rational attributes, while language arts is associated with feminine-expressive attributes (Colley & Comber, 2003). This gendered context likely influences the production and content of the textbooks themselves. Authors and publishers creating materials for a subject perceived as masculine may be more likely, whether consciously or unconsciously, to select content that aligns with these existing stereotypes. This pattern reflects the complex nature of textbook production, involving intricate interactions between policy mandates, curriculum development, publishing cycles, and authorial choices (Höhne, 2018; Matthes et al., 2024; Young & Muller, 2016). Textbooks then present this stereotyped view to teachers, parents, and students, whose own biases and expectations are in turn reinforced (van de Rozenberg et al., 2024; van der Vleuten et al., 2016; Wolter et al., 2015), thereby creating a self-perpetuating cycle in which the stereotypes within mathematics textbooks are both a product of, and a contributor to, the subject's gendered culture. Future research should investigate these subject-specific production mechanisms (Hermann, 2016) to better understand how educational policy is interpreted and implemented differently across subject areas (Matthes & Schütze, 2016; Ott, 2017b).

Compounding Effect of Subject and Domain

The intersection of subject area and occupational domain reveals compounding effects on gender representation over time (H5). Female STEM representation in mathematics textbooks remained statistically static over nearly six decades (from 1.4% to 1.0%), a notable result considering many gender equality efforts (Guthridge et al., 2022). Over the same period, this occupational domain showed substantial progress in German language arts textbooks (from 0.0% to 13.3%). While we hypothesized that HEED would show the largest increases, the three-way interaction revealed that the gap between HEED and STEM narrowed over time in both subjects. This pattern reflects the much lower starting point for STEM, which allowed for larger relative gains, even though absolute levels of female STEM representation remained very low. This finding partially contradicts our initial hypothesis. These results provide the first direct demonstration of how subject and domain jointly influence gender representation over time. In our view, the most compelling explanation is that gender stereotypes in textbooks intertwine (McCall, 2005; Yuval-Davis, 2006) with multiple biased contexts (Collins, 1998; Salem, 2018). Within mathematics textbooks, female HEED representation remained lower than in German language arts textbooks, and the difference was even more pronounced in STEM, suggesting that the masculine framing of mathematics constrains female representation even in traditionally feminine occupational domains (Puzio & Valshtein, 2022). This intersectional lens, which examines how multiple forms of bias compound each other, opens new avenues for textbook analysis. This understanding of interconnected contexts and categories (Klinger & Knapp, 2008) is increasingly recognized as a vital, yet still infrequent, perspective in textbook research (Alter et al., 2021; Burden, 2023; Knudsen, 2005, 2006; Koster et al., 2023). There is a need for research to explore educational material with a perspective that goes beyond simple gender representation and includes different biased contexts and categories (Ferree & Hall, 1996).

Practice Implications

Our results have important theoretical and practical implications. From a theoretical perspective, our findings are compatible with social role theory (Eagly & Wood, 2012) by documenting gender-stereotypical textbook representations that may constitute inputs into processes of gender role socialization. Our longitudinal evidence reveals that textbooks may contribute to these divisions through systematic gender-specific representations. The underrepresentation of women in STEM occupations over six decades demonstrates how educational materials can uphold gender stereotypes

that persist despite temporal change (Charlesworth & Banaji, 2022). Most critically, the stagnation of female representation in mathematics textbooks identifies a specific educational context in which the transformation of gender roles appears to fail. While Eagly's framework predicts role change through women's increasing workforce participation (Eagly et al., 2020), progress may be significantly impeded within certain subject-specific contexts. One possible interpretation is that the compounding effect of a masculine-coded subject presenting a masculine-coded occupation creates a context that is highly resistant to reflecting societal change.

Second, our findings provide empirical support for critiques of knowledge production in educational contexts (Apple, 1987; Lässig, 2010; Ott, 2017a). Research on knowledge transmission in educational media (Höhne, 2005; Stein, 1977) emphasizes how textbooks are embedded within political and sociocultural contexts that determine legitimate knowledge. Our results establish that textbook knowledge maintains existing gender hierarchies over a long period of time. The persistent marginalization of women in STEM, particularly in mathematics textbooks, exemplifies what feminist scholars identify as the sociology of knowledge dimension: certain knowledge forms and producers receive systematic privilege over others (Code, 1991; Hill Collins, 2002; Smith, 1987). The uneven progress across subjects and the divergent response to the 1986 policy illustrate the structural resistance of gendered knowledge hierarchies that feminist scholarship identifies (Mills & Mustapha, 2015), particularly in masculine-coded domains like mathematics.

The stagnation of female representation in mathematics textbooks underscores the need for subject-specific interventions in textbook development. From a practical standpoint, publishers and educators must recognize that progress in one domain does not automatically transfer to others. Zala-Mezö et al. (2021), for example, propose implementing formative evaluations during the textbook production process. This approach would be excellent for improving not only the pedagogical content knowledge but also the sociocultural knowledge embedded within school textbooks.

Limitations and Future Research Directions

The present study provides the first large-scale, longitudinal evidence of how gender representation in HEED and STEM occupations has evolved in German language arts versus mathematics textbooks. Despite the overall support for our hypotheses, several limitations of our computational text analysis approach must be acknowledged. First, our computational approach was limited to the running text of textbooks and did not include pictorial elements. Visual representations of occupational roles constitute an important dimension of gender representation in educational materials

(Cruz Neri et al., 2024; Finsterwald & Ziegler, 2007; Moser & Hannover, 2014) and may communicate gender stereotypes in ways different from textual content. Similarly, our word-list-based method captured only explicit occupational nouns and did not identify occupational activity described through sentence-like expressions (e.g., "she works in a drugstore"). Future research combining textual and visual analysis, as well as more sophisticated natural language processing techniques, could provide a more comprehensive picture of occupational gender representation.

Second, our method quantified each occupational mention as an independent data point. Consequently, the analysis did not distinguish between a single character mentioned multiple times within a text and multiple unique characters appearing once. This approach, while necessary for a large-scale corpus analysis, may inflate the frequency counts of characters who are central to a particular narrative. Future research employing more fine-grained text analysis, such as labeling each unique character with an ID, could provide a more nuanced count of individual representations and complement the present frequency-based findings.

Third, our study focused on the presence and proportional share of female versus male occupational terms, but it did not analyze the gender-stereotypical attributes associated with these roles. While our findings reveal who is represented, they do not capture how they are described. Examining whether HEED and STEM roles are described with, e.g., communal or agentic attributes (Abele & Wojciszke, 2007), represents an important gap in understanding how stereotypes are subtly communicated through descriptive language. In terms of future research, it would be useful to extend the current findings by examining gender-stereotypical attribute dimensions (Formanowicz et al., 2017; Pietraszkiewicz & Formanowicz, 2023; Pietraszkiewicz et al., 2019) related to occupational mentions, which would provide deeper insight into the qualitative nature of these occupational portrayals.

Fourth, our analysis was limited to binary gender based on grammatical markers and did not examine gender-fair language use. This included our consistent coding of all potentially generic masculine nouns as male, as disambiguating their specific referent was not feasible across the large corpus. Both elements significantly impact children's and adolescents' occupational perceptions (Sczesny et al., 2016; Vervecken & Hannover, 2015; Vervecken et al., 2013) and constitute integral components of textbook research (Kiesendahl & Ott, 2015; Moser & Hannover, 2014; Moser et al., 2013). Our binary focus, while reflecting the source material's linguistic structure, cannot capture non-binary or gender-diverse individuals. Future research should combine occupational role analysis with gender-inclusive language investigation and develop methodologies for identifying

non-binary representations in educational materials (Höhne & Heerdegen, 2018; Koster et al., 2025).

Despite these limitations, the merit of the present study lies in its corpus linguistic quantitative approach, which enabled a complete analysis of all approved Bavarian mathematics and German language arts textbooks from 1960 to 2017. By evaluating a substantially larger number of textbooks than previous studies and employing a discontinuity design to test the impact of the 1986 policy, this work provides a comprehensive comparison of subjects (mathematics vs. German language arts) and domains (STEM vs. HEED), offering a more detailed longitudinal perspective on the persistence of occupational gender stereotypes.

Conclusion

Our findings establish that while female occupational representation has generally increased since 1960, this trend is significantly moderated by both occupational domain and subject. Notably, the 1986 governmental resolution on gender equity had divergent effects: German language arts textbooks showed a positive change, while mathematics textbooks showed no improvement or even a decline of female representation. German language arts textbooks show progress in representing women across both HEED and STEM domains. In contrast, mathematics textbooks showed slower progress in HEED representation compared to German language arts textbooks, and maintain STEM as an almost exclusively male domain, a trend unchanged for nearly six decades. This complete stagnation in female representation in STEM occupational roles highlights cause for action, especially as textbooks serve as crucial socializing agents during formative developmental periods when children and adolescents internalize occupational stereotypes that can shape their career trajectories. Our results call for targeted efforts by publishers and educators to create materials that reflect and encourage a more inclusive vision of the modern workforce.

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Data Availability The data that support the findings of this study are available from the corresponding authors upon reasonable request.

Declarations

Ethics Approval and Consent No human participants or animals are involved in this study, and no informed consent was required.

Research Involving Human Participants and/or Animals No human participants or animals are involved in this study.

Informed Consent No informed consent was required.

Competing Interests The authors declare that there is no conflict of interest.

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Appendix C: Study III

Horizontal and vertical occupational gender segregation in German occupational orientation textbooks

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Horizontal and vertical occupational gender segregation in German occupational orientation textbooks

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Abstract

Women continue to predominate in healthcare, early education, domestic work (HEED), and service occupations, whereas men dominate in science, technology, engineering, and mathematics (STEM) and skilled trades occupations globally. Educational materials can influence adolescents' career aspirations and play a crucial role in reinforcing or challenging occupational segregation. Although previous studies have documented gender representation in textbooks broadly, analyses of occupational orientation materials that examine both horizontal and vertical segregation in a differentiated manner are lacking. We analyzed 19 German secondary school textbooks from subjects focused on occupational orientation (Economics and Careers and Economics and Communication), assessing the gender distribution across different occupational domains and hierarchical levels in 1,195-character portrayals (959 textual, 236 visual). Results revealed that women were depicted significantly less frequently than men overall, primarily due to textual representations. Regarding horizontal segregation, women were overrepresented in HEED/service occupational roles (64.0%), while men dominated STEM/skilled trades occupational roles (77.9%). Vertical occupational segregation was only found in textual representations. Within female-dominated occupational domains, women were disproportionately represented in low-status roles, comprising 78.7% of characters at that level. Within male-dominated occupational domains, men were significantly overrepresented across all hierarchy levels, with the disparity being most pronounced at the lowest hierarchy level, where no women were depicted. These results suggest the need to revise educational materials, offering a constructive perspective for creating more equitable gender representations in occupational fields that can genuinely expand adolescents' career horizons.

Keywords Occupational gender segregation · HEED · STEM · Gender stereotypes · Textbooks

Extended author information available on the last page of the article

1 Introduction

Women and men continue to work in markedly different occupations and hold unequal positions within organizational hierarchies across global labor markets (England et al., 2020; Torre & Jacobs, 2021). Despite decades of legislative reforms and growing awareness of gender equality, this segregation remains remarkably stable: women still are concentrated in occupational roles in health care, early education, domestic work (HEED), and service occupations, while men dominate science, technology, engineering, mathematics (STEM) professions, and skilled trades (World Economic Forum, 2023). This horizontal division combines with vertical segregation, as men hold disproportionate numbers of leadership and high-level positions even within female-dominated occupational domains (OECD, 2023). These disparities drive persistent wage gaps, restrict career advancement opportunities, and reinforce societal gender stereotypes (Blackburn & Jarman, 2006).

Educational materials contribute to occupational segregation during adolescence, a period when career aspirations crystallize, and gender role perceptions solidify (Eccles, 2011). Textbooks, as educational materials used almost daily, serve as powerful socializing agents that shape students' understanding of occupational possibilities and social norms (Apple & Christian-Smith, 1991). How these materials portray gender in occupational roles may therefore play an important role in shaping young people's perceptions of career appropriateness and their professional aspirations (Good et al., 2010; Olsson & Martiny, 2018; Scott & Feldmann-Summers, 1979).

However, critical gaps remain in our understanding of how contemporary educational materials portray occupational gender segregation. Three key limitations characterize existing research. First, although studies document women's general underrepresentation in occupational roles (Moser, 2016; Ott, 2021), few have systematically examined horizontal segregation, i.e., the concentration of gender in specific occupations, using contemporary domain classifications like HEED, STEM, services, and skilled trades that reflect current labor market divisions ([blinded for review]; Kerkhoven et al., 2016). Second, vertical segregation, which refers to the distribution of gender across hierarchical occupational levels, has received insufficient attention (Ott, 2017). Third, researchers have examined textbooks from various subjects, but have neglected specialized occupational orientation textbooks that address students' understanding of occupational possibilities.

We address these limitations by conducting a content analysis of officially approved German secondary-school textbooks for occupational orientation that examines both horizontal and vertical occupational gender segregation, using contemporary occupational domain classifications. Our results help determine whether contemporary occupational orientation textbooks reflect or challenge existing occupational gender segregation, providing crucial insights for developing more equitable educational resources that support diverse career aspirations during adolescence.

1.1 The role of curricula and textbooks in occupational orientation

Curricula function as state instruments for directing and standardizing education, specifying essential content, learning objectives, and competencies for different sub-

ject areas, school types, and grade levels (Stevenson & Baker, 1991). These frameworks articulate educational goals while embedding societal values, educational philosophies, and political priorities that shape students' learning experience (Apple, 2019; Moore, 2015; Young & Muller, 2016).

Many curricula, particularly at the secondary level, include occupational orientation to prepare students for future professional and personal life by providing information about diverse career paths, developing job-relevant skills, and drawing connections between education and employment (Guichard, 2001). For instance, the curriculum of the German Federal State of Bavaria explicitly prioritizes occupational orientation to facilitate informed career decisions and successful transitions into vocational training or further education (ISB, 2025). This curricular focus is implemented through textbooks in core subjects specifically designated for career guidance, such as Economics and Careers (*Wirtschaft und Beruf*) and Economics and Communication (*Wirtschaft und Kommunikation*).

Textbooks enable the practical implementation of these curricula's contents, serving as the primary resource for both teachers and students (Gautschi, 2018; Stará et al., 2017). They translate official guidelines into practical instructional materials, including texts, exercises, and illustrations, that structure teaching and learning and thus function as important mediators between official learning goals and classroom practice (Schmidt et al., 1997).

As relevant socializing agents, textbooks are widely argued to shape students' learning experiences and their understanding of the world (Apple & Christian-Smith, 1991; Tyson-Bernstein, 1988). Foundational work in this area posits that the ways these materials portray social groups and occupational roles influence students' understanding of social norms, their beliefs, and their identity formation (Behnke, 2018; Curdt-Christiansen, 2017). There is also a growing body of experimental research that supports this link. For instance, studies from psycholinguistics have shown that the use of gender-fair language in occupational descriptions can influence children's and adolescents' perceptions of those roles (Horvath et al., 2015; Vervecken et al., 2015; Vervecken & Hannover, 2015), and experimental studies have found that counter-stereotypical images can impact student performance (Good et al., 2010). Given that portrayals of occupational roles and domains often reflect traditional gender stereotypes (Arnot, 2002; Moser, 2016; Ott, 2021), it seems plausible that textbooks might perpetuate gender disparities through the subtle signals they send about who belongs in which occupational roles.

Through the theoretical lens of Social Role Theory (Eagly, 1987; Eagly & Wood, 2012) and Gottfredson's Theory of Circumscription, Compromise, and Self-Creation (Gottfredson, 2002), gendered representations in textbooks contribute to the internalization of occupational stereotypes during adolescence. When educational materials predominantly depict women and men in traditional roles, they reinforce perceptions that certain occupations suit one gender more than another, thus potentially limiting adolescents' occupational aspirations and shaping their career choices (Eccles, 2009; Weisgram et al., 2010). Analyzing gender representation in textbooks, particularly those addressing occupational orientation, is therefore essential for elucidating their potential impact on students' career aspirations and the reproduction of gender disparities.

1.2 Horizontal and vertical gender occupational segregation and their depiction in textbooks

Occupational gender segregation, the systematic concentration of women and men in different occupations and hierarchical positions, persists across contemporary labor markets (Jarman et al., 2012; Wong & Charles, 2020). As Schmader and Nater (2025) delineate, this segregation manifests in two interconnected yet distinct dimensions: horizontal and vertical segregation. Horizontal segregation refers to the unequal distribution of women and men across various occupations and industries. In contrast, vertical segregation refers to the uneven distribution across hierarchical levels within the same occupation, with men typically occupying higher-status, better-compensated positions. This section examines each segregation dimension by reviewing the existing literature and identifying research gaps.

1.2.1 Horizontal occupational gender segregation

Female-dominated occupational domains cluster primarily in two major categories: HEED (health care, early education, and domestic work) and broader service occupations (ILO, 2018; World Economic Forum, 2023). HEED roles involve care, nurturing, and social support functions, including nursing, teaching, and social work, while service occupations encompass retail, administrative, hospitality, and customer service roles such as secretaries, sales associates, and restaurant staff (Croft et al., 2015). These roles are associated with stereotypically feminine attributes like nurturing, warmth, and empathy (Froehlich et al., 2020; Sczesny et al., 2018), which align with what research identifies as communal attributes—qualities related to social connection, empathy, and helpfulness that are stereotypically attributed more strongly to women (Abele et al., 2016; Sczesny et al., 2018). Beyond their alignment with gender stereotypes, these occupational roles fulfill essential functions in health support, individual development, and community cohesion.

Labor market data demonstrate the extent of horizontal segregation, specifically the overrepresentation of females in these domains. Globally, women constitute approximately 70% of the health and social work workforce (Boniol et al., 2019). Similar patterns emerge nationally: for example, women comprise 74% of education and health services workers in the U.S.; in Germany, this figure reaches 77% (Bundesagentur für Arbeit, 2024; U.S. Bureau of Labor Statistics, 2023). This high female participation extends to the broader service domain in some countries (World Economic Forum, 2023). For example, national data show that women comprise approximately 65% of the general services workforce in Germany (Bundesagentur für Arbeit, 2024).

In contrast, male-dominated occupational domains center on STEM (science, technology, engineering, and mathematics) and skilled trades (World Economic Forum, 2023). STEM encompasses a range of occupations from research scientists, engineers, and computer professionals to specialized technicians (Fayer et al., 2017). Skilled trades include work in construction, manufacturing, and mechanics (National Center for Science and Engineering Statistics, 2023). These occupational domains are culturally associated with agency, which refers to attributes such as assertive-

ness, technical competence, and independence—qualities stereotypically ascribed to men (Abele et al., 2016; Abele & Wojciszke, 2007). These domains embody what Cheryan and Markus (2020) called “masculine defaults,” referring to environments and systems created by and for one gender that contain subtle signals of inclusion for men and exclusion for women.

In STEM domains, despite concerted efforts to increase female participation, women account for only 29% of the global workforce (World Economic Forum, 2023). National figures are lower in many countries. For example, in the U.S., only 18% of women work in STEM domains (National Science Board & National Science Foundation, 2024) and 17% in Germany (Bundesagentur für Arbeit, 2024). Skilled trades show similar male dominance, with women comprising only around 22% of the workforce worldwide (World Economic Forum, 2023), and even lower numbers in some countries (e.g., 11.0% women in the U.S. construction workforce and 12% in Germany; Bundesagentur für Arbeit, 2024; U.S. Bureau of Labor Statistics, 2023).

1.2.1.1 Research on horizontal segregation in textbooks Previous studies examining horizontal segregation in educational materials consistently demonstrated that textbooks reflect the gendered division of occupations (Finsterwald & Ziegler, 2007; Moser & Hannover, 2014; Ott, 2017). Early investigations predominantly used terms like “typical” or “traditional” female/male occupational domains without using contemporary domain classifications like HEED or STEM, showed that women were mainly depicted in teaching, nursing, and secretarial work, while men appeared in broader ranges involving authority and technical skills (Evans & Davies, 2000; Lindner & Lukesch, 1994; Weitzman et al., 1972). For example, Lindner and Lukesch (1994) conducted a content analysis of 72 textbooks from Germany published between 1971 and 1992, covering German language arts, mathematics, basic sciences, and religion in primary and secondary education. Their analysis found significant horizontal segregation. Among 9,471 individuals depicted, women constituted only 32% of all characters. Their representation in occupational roles was disproportionately low, with only 13%. Among the 2,225 coded occupational roles, a clear gendered division emerged: 35% were typically female occupations (e.g., social care, sales, and hairdressing), in which women accounted for 62%. In contrast, 36% were in typical male occupations (including doctors and police), with only 12% of women depicted. The disparity was also evident in the images: among 6,992 individuals depicted, females accounted for 39%. Among the 797 coded occupational roles depicted in pictures, women accounted for only 16%.

Finsterwald and Ziegler (2007) reported similar results in their analysis of approximately 300 illustrations from 28 German-language arts and basic sciences textbooks for grades 1–4, published in Germany between 1996 and 2001. They observed significant male dominance in illustrations (59% male vs. 40% female). Adult men were more frequently depicted in occupations ($n=210$) than women ($n=74$), excluding the homemaker role. Within these occupational depictions, the distribution was asymmetric: 59% of the men ($n=124$) appeared in male-dominated roles, while 93% of the women ($n=69$) appeared in female-dominated roles. A notable crossover was observed for men, with 41% ($n=86$) shown in female-dominated occupations,

whereas only 7% of women ($n=5$) were depicted in male-dominated fields. The most frequent examples of male-dominated roles in which men appeared were craftsmen, farmers, and drivers, while female-dominated roles were most often teachers, saleswomen, nurses, and secretaries. A key finding concerns the gendered portrayal of technology use within occupations: Women were overwhelmingly depicted in situations requiring little to no technical knowledge, whereas men appeared in roles demanding moderate to high technical knowledge. While this study revealed a clear occupational segregation, its focus on general occupational categories rather than contemporary occupational classifications, such as HEED and STEM, limits direct comparisons with contemporary segregation frameworks.

In a linguistic analysis of 88 German-language and mathematics textbooks from Germany (and its predecessor states) from 1890 to 2013, Ott (2017) found that occupational activity was consistently portrayed as a male domain. At the lexical level, male-referring occupational terms appeared twice as frequently as female-referring terms. Certain occupational domains, such as those related to entrepreneurship, finance, construction, transport, law, military/police, and politics, were almost exclusively male-dominated. Men were frequently depicted in occupations that required heavy physical labor, such as craftsmen and laborers. In contrast, women were often depicted in occupations typically associated with nurturing or caregiving, such as teaching and nursing. Ott's study also highlighted that women were less frequently associated with technical devices. At the same time, men were predominantly shown using technical objects that required advanced technical knowledge, complex transportation means, and weapons. Although Ott's historical analysis provided valuable insights into gendered occupational discourse, the absence of specific HEED and STEM categorization makes it challenging to assess horizontal segregation within these critical domains.

Only a few studies used the contemporary categorizations of HEED and/or STEM when investigating horizontal occupational segregation in educational materials. Kerkhoven et al. (2016) conducted a visual content analysis of 333 online science education resources from the websites of Scientix (an EU-wide initiative) and OER-commons (a global library) for primary schools, analyzing 3,191 depicted individuals across astronomy, biology, chemistry, geology, mathematics, physics, and technology materials. The study revealed pronounced horizontal segregation: for example, men accounted for 75% of those depicted in science occupations, whereas women accounted for 25%. In contrast, females were more often depicted in teaching roles (classified as non-STEM by the authors) than men (64% versus 36%). While this study demonstrated gender segregation in STEM and non-STEM occupations, it did not analyze gender segregation within HEED occupational domains. Furthermore, it investigated online resources rather than textbooks. [blinded for review] employed quantitative text analysis of 202 current German language arts textbooks from Germany, using systematic occupational classifications to examine STEM and care work (HEED) occupational terms. Their findings revealed pronounced horizontal segregation in STEM occupations, with men comprising 86% and women 14%. Unexpectedly, men were also overrepresented in care work occupations (74% vs. 26% women), suggesting that employment is portrayed as predominantly masculine. While this study represents the first systematic examination of both HEED and

STEM in German language arts textbooks, the analysis focused on textual content, limiting insights into both visual representations and the specific activities or contexts associated with occupational portrayals.

1.2.1.2 Research gaps in textbook research on horizontal segregation Despite this established body of research, several gaps remain in our understanding of horizontal segregation in textbooks. First, older studies typically categorized occupations as predominantly female or predominantly male (Lindner & Lukesch, 1994; Weitzman et al., 1972). And, although there has been a shift in recent years to use more systematic, contemporary classifications (Asadullah et al., 2018; Crawford et al., 2024; Fruehwirth et al., 2024; Jehle et al., 2024), a comprehensive analysis that includes HEED and STEM as well as the gendered occupational domains of services and skilled trades is still a desideratum in the literature. Second, existing research has predominantly examined general subject textbooks (Cruz Neri et al., 2024; Jehle et al., 2024; Moser & Hannover, 2014; Ott, 2017) or other educational media. To our knowledge, a systematic analysis of specialized occupational orientation textbooks, materials with an explicit curricular mandate to guide students' career choices, is still lacking. Given that these materials are central to career preparation, this represents a significant gap. Third, many studies have analyzed either textual content (Fruehwirth et al., 2024) or visual representation (Finsterwald & Ziegler, 2007; Kerkhoven et al., 2016) in isolation. A key goal of the present study is to address these gaps by systematically analyzing both text and images in specialized career orientation textbooks, using a comprehensive four-part domain classification (HEED, services, STEM, and skilled trades).

1.2.2 Vertical occupational gender segregation

Vertical occupational gender segregation refers to the hierarchical dimension of occupational inequality, characterized by the unequal distribution of women and men across levels of authority, responsibility, and compensation within occupational domains (Blackburn et al., 2001). This form of segregation manifests as women's underrepresentation in positions of leadership and power, with men typically dominating high-level roles even when women constitute significant portions of the overall workforce within those domains. Despite progress toward greater gender equality, women advance to top leadership positions at lower rates than men, with disparities evident across both political and economic spheres (Blau & Lynch, 2024). Unlike horizontal segregation, which separates occupational domains by gender, vertical segregation creates hierarchical barriers within domains, limiting women's advancement to higher positions despite their numerical presence in those domains (Perales, 2013; Schmader & Nater, 2025).

Vertical gender segregation persists even within female-dominated occupational domains. While women comprise nearly 70% of the global health workforce, they hold only 25% of senior leadership roles (ILO & World Health Organization, 2022; World Health Organization, 2019). Similar patterns emerge at the country level. For example, in the U.S. health care sector, women constitute 62% of the overall work-

force but hold only 44% of senior leadership positions. Similarly, in education, their share drops from 54% of the workforce to 44% at the leadership level (Lara & Baird, 2024). In Germany, women comprise 78% of the workforce in female-dominated occupational segments (such as the medical and non-medical health sector and social and cultural service occupations) but hold only 52% of leadership positions in these domains.

Vertical segregation in male-dominated STEM and skilled trades presents a paradox that challenges simple exclusion narratives. While women comprise only 29% of the global STEM workforce, reflecting severe horizontal segregation at entry (World Economic Forum, 2023), vertical progression for women who do enter these domains shows considerable cross-national variation. Global aggregated data suggests continued underrepresentation at senior levels, with women holding 18% of senior leadership and 12% of top executive roles (World Economic Forum, 2023). However, national data reveal a more complex picture. In the U.S. federal sector, women hold 25.9% of STEM leadership positions, compared with 29.3% of the overall STEM workforce (EEOC, 2019). In Germany, although women are underrepresented in male-dominated technical occupations (Bundesagentur für Arbeit, 2024), they significantly outperform their male colleagues in advancement: 35.3% of women reach specialist (with complex work activities) or expert (with highly complex work activities) levels compared to only 27.5% of men in the same domain (Vicari et al., 2023).

1.2.2.1 Research on vertical segregation in textbooks Compared with general occupational gender representation and horizontal segregation, vertical segregation has received considerably less attention in textbook research (Moser, 2016; Ott, 2021). Some studies have investigated related issues and have yielded inconsistent findings (Finsterwald & Ziegler, 2007; Ott, 2017).

Finsterwald and Ziegler (2007) found no significant gender differences regarding the general depiction of dominance in social situations. Women were shown in dominant roles, such as instructing others, almost as frequently as men (women were coded as “dominant” in 63% of applicable situations, with no statistically significant difference from men), challenging stereotypes of female submissiveness. A different picture emerged for educational attainment as implied by occupations. Men were more frequently depicted in occupations that required no specific diploma or a basic secondary school education, often involving physical labor. Specifically, the percentage of men shown in jobs requiring no diploma was 16.5% points higher than the percentage of women shown in such jobs. Similarly, for jobs requiring a basic secondary school diploma, the male share was 10.5% points higher than the female share. In contrast, women were more likely to be depicted in occupations requiring university degrees (a 17.2%-point overrepresentation relative to men). While this was among the first studies to examine vertical segregation, the analysis employed indirect measures, such as educational attainment, and focused on behavior rather than conducting a systematic examination of hierarchical job titles or compensation.

In an extensive study, Ott (2017) identified more pronounced vertical segregation through discourse-linguistic analysis of 88 German textbooks published between 1890 and 2013. Based on a qualitative interpretation of occupational titles, Ott found

that male job titles consistently spanned broad hierarchical ranges, often using explicit leadership markers (e.g., suffixes denoting “master” or “leader”). In contrast, female titles lacked these markers, with status distinctions shown through separate words (e.g., “farm owner” vs. “farmhand”). Women first appeared in leadership roles in the 1960s, initially restricted to female-dominated occupational domains, and were frequently portrayed in subordinate roles, such as secretaries, particularly from the 1980s to the 2000s. While providing rich qualitative insights, Ott’s linguistic focus lacked a systematic quantitative framework for analyzing vertical segregation across predefined occupational hierarchical levels.

More recently, Guichot-Reina and La Torre-Sierra (2023) conducted a critical discourse analysis of six current Spanish elementary mathematics textbooks that explicitly documented vertical segregation. The study showed that when characters were depicted in high-status occupational positions such as bosses, directors, or mayors, men occupied these roles 69% of the time, whereas women occupied them 31% of the time. These hierarchical differences in occupations were reinforced through qualitative examples, such as a male headmaster supervising a female teacher. Although employing a comprehensive classification of occupational status levels, the study focused explicitly on high-status roles.

1.2.2.2 Research gaps in vertical segregation in textbooks Although existing research on vertical segregation in gender-stereotypical occupational representation in textbooks gives some important insights, several research gaps remain. First, to our knowledge, no study has investigated vertical segregation within contemporary occupational domains, such as HEED and STEM, nor examined whether textbooks accurately reflect the nuanced pictures of women’s advancement documented in contemporary labor market studies, or present oversimplified narratives that may not align with empirical evidence. Second, the conceptualization of vertical segregation is often methodologically simplistic and lacks firm theoretical grounding. Studies have employed indirect categories, such as educational attainment (Finsterwald & Ziegler, 2007), or basic counts of high-status titles (Guichot-Reina & La Torre-Sierra, 2023), rather than applying a systematic classification of occupational vertical segregation. Third, as with gaps in research on horizontal segregation, analyses have focused on general subject textbooks (Moser & Hannover, 2014; Ott, 2017) rather than specialized occupational orientation materials designed to support career choices. Finally, most studies analyze either textual or visual representations in isolation, overlooking the interplay between language and images in the construction of hierarchical occupational gender roles.

2 Current study

Past research on textbooks reveals significant gaps in understanding both the horizontal and vertical dimensions of occupational gender segregation. Although a vast body of research exists on horizontal segregation, most studies used broad occupational categories (e.g., “typically female” vs. “typically male”) rather than contempo-

rary classifications, such as HEED and STEM. Research on vertical segregation has only received limited attention, with the few studies examining hierarchical gender segregation focusing on simplistic vertical categories. Furthermore, a simultaneous investigation of both text and images is lacking. Finally, existing research has predominantly focused on general subject textbooks rather than specialized textbooks for occupational orientation. These gaps are particularly significant given that occupational orientation textbooks provide adolescents with essential guidance during a developmental period when occupational aspirations solidify, thus potentially reinforcing gender stereotypes that contribute to persistent occupational gender segregation (Eccles, 2011; Korlat et al., 2023). To address these limitations, the current study systematically examines both horizontal and vertical occupational gender segregation in German secondary school occupational orientation textbooks, materials specifically designed to meet curricular specifications for career orientation and guidance. Based on current gender distributions in national and international labor markets, we investigate horizontal segregation by categorizing occupations into female-dominated occupational domains, such as HEED occupations and services, and male-dominated occupational domains, such as STEM occupations and skilled trades. We investigated vertical segregation by classifying occupations within each domain into three hierarchical levels (low, medium, and high) based on sociological frameworks and standardized occupational classification systems that incorporate factors such as required qualifications, responsibility level, and typical remuneration (Blackburn et al., 2014; Bundesagentur für Arbeit, 2021; ILO, 2023). We investigate horizontal and vertical gender occupational representation in both text and images.

Given the extensive literature documenting persistent occupational gender imbalances, with women being less frequently depicted than men in occupational roles (Ott, 2021), we hypothesize:

Hypothesis 1 *Women are depicted less frequently than men in occupational roles in German occupational orientation textbooks.*

Concerning horizontal segregation, given that HEED and services domains are typically female-dominated, and STEM occupations and skilled trades are typically male-dominated (Tellhed et al., 2017), we hypothesize:

Hypothesis 2 *Women are depicted more frequently within female-dominated occupational domains (HEED and services) and less frequently within male-dominated occupational domains (STEM and skilled trades).*

Concerning vertical segregations, due to existing research and the tendency for men to occupy and be associated with higher-level positions (Blackburn et al., 2014), we hypothesize:

Hypothesis 3a *In female-dominated occupational domains (HEED and services), men are disproportionately represented in high-level occupational roles, while women are disproportionately represented in low- and medium-level occupational roles.*

Hypothesis 3b *In male-dominated occupational domains (STEM and skilled trades), men are disproportionately represented at all occupational levels (high, medium, and low).*

To test our hypotheses, we conducted a content analysis of German secondary school occupational orientation textbooks, encompassing both text and images. We then employed descriptive and inferential statistical analyses to examine the resulting frequency data in relation to our hypotheses.

3 Method

3.1 Sample

The study sample comprised 19 German secondary school textbooks explicitly designed for occupational orientation education and officially approved between 2017 and 2022. These textbooks are used in Bavaria, one of Germany's 16 federal states, which maintains a three-track secondary education system: an academic track preparing for university (Gymnasium), an intermediate track (Realschule), and a vocational-oriented track (*Mittelschule*). We focused on textbooks from the vocational-oriented track (*Mittelschule*) because this educational pathway places the strongest emphasis on occupational orientation and practical career preparation, with students typically transitioning directly to vocational training or employment after graduation.

We selected textbooks based on three criteria: (a) official approval by the Bavarian State Ministry for Education and Cultural Affairs, (b) explicit coverage of occupational orientation competencies as specified in the Bavarian curriculum (*LehrplanPLUS*) through the two core subjects designated for occupational orientation instruction in the vocational-oriented track (*Mittelschule*) curriculum: Economics and Careers (*Wirtschaft und Beruf*) and Economics and Communication (*Wirtschaft und Kommunikation*), and (c) publication after the 1986 German federal resolution promoting fair gender representation in educational materials (KMK, 1986), which mandated that textbooks present women and men equally in various social and occupational roles. The final sample comprised all available textbooks for these subjects: 14 from Economics and Careers (covering Grades 5–10) and five from Economics and Communication (covering Grades 7–10). Online Appendix A provides detailed characteristics of the textbook sample.

3.2 Coding instrument development

To code occupational representation concerning horizontal segregation (HEED/ services, STEM/skilled trades) and vertical segregation (hierarchical occupational levels), we adapted a validated coding instrument developed initially by Moser et al. (2013) for analyzing gender representation in both textual and visual content in educational materials (Moser & Hannover, 2014). Based on qualitative content analysis principles (Mayring, 2014), we refined the coding framework to capture

detailed occupational portrayals while maintaining the original instrument's validated approach.

The original instrument comprises six scales for text and image coding, including categorization of text types and images, character identification, language analysis, actions, and locations of actions. For our adaptations, we retained the methodological approach and the scales for text/image categorization, character identification, and language analysis, particularly the validated procedures for gender identification. We excluded scales assessing actions and locations after pretesting revealed that they did not contribute to our research questions regarding occupational representation. Most significantly, we expanded the instrument by developing new scales to systematically capture occupations according to horizontal domains (HEED, services, STEM, skilled trades) and vertical segregation levels.

To ensure the content validity of our occupational coding (Neuendorf, 2011), we undertook two steps. First, we aligned our coding categories with both the official occupational classifications of the German Federal Employment Agency (Bundesagentur für Arbeit, 2021) and empirical evidence showing that HEED and STEM constitute opposing poles of occupational segregation (Croft et al., 2015; Fayer et al., 2017). Prior research indicates that textbooks frequently depict women in female-dominated domains while underrepresenting them in male-dominated domains (Ott, 2021). This alignment ensured that our occupational domains captured both current labor market structures and documented patterns of gendered occupational representation. Second, we constructed our vertical segregation scale based on theoretical frameworks addressing gender and work, incorporating hierarchical distinctions in qualification requirements, skill levels, income, and occupational prestige (Blackburn et al., 2002; Wong & Charles, 2020).

The unit of analysis was each character presented within a clear occupational context. For textual representations, we coded nouns or pronouns directly associated with occupational titles (e.g., “the engineer,” “she is a nurse”) or with descriptions of occupational activities (e.g., “she is treating patients”). For visual representations, we coded distinct human figures shown performing occupational tasks, wearing occupation-specific clothing (e.g., lab coats, hard hats), or situated in clearly occupational settings (e.g., hospitals, construction sites). We employed parallel coding procedures for text and images, using both shared categories (gender, occupational domain, vertical level) and modality-specific categories. Specifically, text-specific categories included linguistic gender markers and pronoun usage, while image-specific categories included visual gender cues and occupational symbols. When text and accompanying images clearly represented the same individual or occupational context (e.g., a caption reading “Dr. Schmidt” beneath an image of a person in medical attire), coders synthesized information from both modalities to assign consistent codes for gender identification, occupational domain, and vertical segregation level.

3.3 Coding categories

3.3.1 Gender categories scale

After identifying individual characters depicted in occupational contexts, we coded each character's gender separately using the following process. For textual depictions, we first determined the type of gender evidence (e.g., explicit gender-specific terms, specific personal names, or gender-fair language forms). Based on this evidence, we assigned characters to an initial category. Characters were coded as male (1) or female (2) when identified through explicit gendered terminology (e.g., *Frau/Mann* [woman/man]), clearly gendered personal names, or gender-specific grammatical forms (e.g., *der Bäcker* [the baker, masc.] for male¹; *die Ärztin* [the doctor, fem.] for female). We assigned characters to a neutral/gender-fair (3) category when an intentionally inclusive or grammatically neutral German term was used (e.g., the neutral noun *Lehrkraft* [teaching staff], an abbreviated gender-inclusive form like *Lehrer/-in* [male/female teacher], or an explicit pairing like *eine Richterin oder ein Richter* [a female judge or a male judge]). In cases of ambiguity or insufficient information where a gender could not be determined (e.g., a unisex name like Alex [Alexandra/Alexander] without further cues), characters were coded as unassignable (0). For image depictions, we coded characters directly as male (1), female (2), or unassignable (0) based on visual cues and contextual information.

For the final statistical analyses, we consolidated these initial codes into a single four-level analytical variable, also referred to as the gender category. The unassignable category (0) included all characters coded as such from either text or images. The male category (1) and female category (2) likewise combined the respective codes from both modalities. The neutral/gender-fair category (3) consisted exclusively of characters identified as such from textual depictions. This consolidated gender category variable was used for all analyses reported in the Results section.

3.3.2 Horizontal occupational segregation scale

We initially planned to classify occupational roles depicted in texts and images into domains based on prior research (e.g., HEED, STEM, other). However, pretesting revealed that roles frequently coded as “other” were numerous and clustered into distinct occupational types. Consequently, drawing inductively from the material during the pretest phase, we refined the coding scheme to include five primary domains: HEED (health care, early education, domestic work; code 1), STEM (science, technology, engineering, mathematics; code 2), skilled trades (e.g., bricklayers, electricians, carpenters; code 3), service occupations (e.g., retail sales staff, secretaries, hairdressers; code 4), and other domains (e.g., athletes, truck drivers, farmers; code 5). Roles that could not be classified were marked as “unassignable” (code 0).

¹ We acknowledge the linguistic debate regarding the *generic masculine* in German (Stahlberg et al., 2007), where a grammatically masculine noun (e.g., *der Lehrer*, [male teacher]) can be intended to refer to individuals of any gender. Our initial coding scheme included a category for this, but no instances in our sample could be unambiguously identified as generic. Therefore, for coding consistency, all grammatically masculine occupational titles were operationally coded as “male”.

For statistical analysis, we aggregated these domains into contemporary occupational categories that reflect documented gender-stereotyped occupational distributions. We combined HEED and service occupations into “female-dominated occupational domains” (FDOD), and STEM and skilled trades into “male-dominated occupational domains” (MDOD). These aggregated categories (FDOD and MDOD) are used throughout the Results section.

3.3.3 Vertical occupational segregation scale

Following sociological frameworks (Blackburn, 2012; Wong & Charles, 2020) and aligning with the German Federal Employment Agency’s classifications (Bundesagentur für Arbeit, 2021), we categorized occupational roles according to vertical segregation criteria, including hierarchical level, qualification requirements, compensation indicators, and societal status. We distinguished three hierarchical levels (high, medium, low) using the following criteria:

3.3.3.1 High-level This category encompasses leadership roles, positions that involve substantial responsibility and complex decision-making, with high qualification requirements (typically university degrees or master craftsman certification) and high societal status/income (e.g., physicians, executives, master craftspeople, engineers in leadership roles).

3.3.3.2 Medium-level This category includes occupational roles and positions requiring intermediate responsibility, typically vocational training or bachelor’s-level qualifications, professional tasks often without leadership functions, and average societal status/income (e.g., teachers, nurses, childcare professionals, mechanics, technicians).

3.3.3.3 Low level This category includes occupational roles and positions characterized by minimal responsibility, lower qualification requirements (often unskilled or semi-skilled), routine or simple tasks, and lower societal status/income (e.g., cleaning staff, assembly line workers, cashiers, entry-level service workers).

3.4 Data collection procedure

The final dataset comprised 1,195 coded instances of occupational roles extracted from 19 occupational orientation textbooks, consisting of 959 textual and 236 image representations. We obtained this dataset through the following procedure: First, we identified chapters that explicitly addressed occupations and work-related topics in each sampled textbook. Second, given the extensive nature of relevant content within these chapters, we employed a systematic random sampling strategy consistent with established content analysis methodologies (Neuendorf, 2011). Specifically, for the relevant chapters within each of the 19 textbooks, we first created a numbered list of

all page numbers eligible for sampling. We then used the Random.org random integer generator to generate a list of unique random numbers corresponding to 50% of the textbook's pages. The pages corresponding to these randomly generated numbers constituted the final sample for coding. This approach ensured proportional representation across all textbooks while managing coding workload. Finally, two trained coders coded all occupational characters (textual and visual) appearing on these selected pages according to the coding categories described above. Each appearance was coded as an independent instance (i.e., a token-based approach). For example, if the same character (e.g., "the engineer") appeared three times on a selected page, it was coded as three separate instances. This approach was chosen to capture the overall frequency of exposure to different types of gendered portrayals.

3.5 Interrater reliability assessment

We conducted a pretest using two textbooks randomly selected from the initial pool (which were subsequently excluded from the main analysis). The two trained coders, the first author and a student research assistant who had received training, collaboratively performed this pretest, refining the coding manual to ensure consistent interpretations and operational definitions of categories. The pretest focused on explicitly identifiable occupational characters, defined as individual figures in text or images associated with a named or visually implied occupation.

For the main analysis, these two trained coders analyzed all textual and visual data from the selected textbook pages. We evaluated interrater reliability using a randomly selected subsample of two textbooks consistent with established content analysis recommendations (Neuendorf, 2011). This subsample, representing 10% of the final sample and comprising 333 coded characters, was coded independently by both coders. After establishing high inter-rater reliability (detailed below), the remaining 90% of the material was divided between the two coders to complete the analysis. Any ambiguities encountered during this main coding phase were resolved through discussion to ensure consistency. We calculated interrater reliability using Cohen's kappa (Cohen, 1960; Fleiss, 1971) via the IRR package (Gamer et al., 2019) in R (version 4.4.2; R Core Team, 2024), supplemented by simple percentage agreement (See Table D1 in Online Online Appendix D for detailed kappa values and percentage agreement per coding category).

Cohen's kappa values for all coding categories ranged from 0.898 to 1.000. These values indicate excellent agreement according to conventional benchmarks ($\kappa > 0.80$ = excellent; $\kappa > 0.60$ = substantial; $\kappa > 0.40$ = moderate; Landis & Koch, 1977; Neuendorf, 2011).

3.6 Data analysis

We conducted all analyses using IBM SPSS Statistics 27, with a statistical significance level set at $\alpha = 0.05$. Descriptive statistics summarized gender category distributions (male, female, neutral/gender-fair, unassignable) across occupational domains and vertical segregation levels. We performed analyses on all occupational depictions

combined (total $N=1,195$) as well as separately for textual (total $N=959$) and image-based (total $N=236$) representations, with specific subsamples detailed below.

To test Hypothesis 1 (H1: Women are depicted less frequently in occupational roles than men), we used chi-square goodness-of-fit tests to compare observed frequencies of “male” versus “female” characters against an expected equal distribution. We conducted this analysis on the combined sample ($N=719$) and separately for the text ($n=496$) and image ($n=223$) subsets.

To test the hypotheses concerning horizontal segregation (H2: Women are depicted more frequently within female-dominated occupational domains (HEED and services) and less frequently within male-dominated occupational domains (STEM and skilled trades), we employed a two-step process. First, we conducted an initial omnibus Fisher-Freeman-Halton exact test (using a Monte Carlo simulation with 10,000 samples) to establish whether an overall association existed between gender category and the six original occupation categories. This omnibus test included all characters with identifiable gender and occupational domain ($N=831$ combined; $n=646$ text; $n=185$ images). Second, to directly test H2, we performed Fisher’s exact tests on 2×2 contingency tables that crossed the “male”/“female” categories with the FDOD/MDOD categories. These focused analyses excluded characters in “other domains” and “domain not specified” categories to examine gender distribution in clearly gender-typed occupational domains. Given the potential for small cell counts in some subgroups (e.g., within image representations), this exact test was deemed the most appropriate procedure (Agresti, 1992; Neuendorf, 2017). We conducted these focused tests for combined data ($N=460$), and separately for text ($n=325$) and images ($n=135$). We used Cramer’s V to quantify effect size.

For the vertical segregation hypotheses (H3a: In female-dominated occupational domains (HEED and services), men are disproportionately represented in high-level occupational roles, while women are disproportionately represented in low- and medium-level occupational roles, and H3b: In male-dominated occupational domains (STEM and skilled trades), men are disproportionately represented at all occupational levels (high, medium, and low), we conducted Fisher-Freeman-Halton exact tests on 2×3 contingency tables to assess associations between gender (“male”/“female”) and segregation level (“high”/“medium”/“low”). We stratified these analyses by domain type and performed them within FDODs (combined $N=242$; text $n=162$; images $n=80$) to test H3a (in female-dominated occupational domains (HEED and services), men are disproportionately represented in high-level occupational roles, while women are disproportionately represented in low- and medium-level occupational roles), and within MDODs (combined $N=213$; text $n=160$; images $n=53$) to test H3b (in male-dominated occupational domains (STEM and skilled trades), men are disproportionately represented at all occupational levels (high, medium, and low). Significant omnibus tests were then followed by pairwise post-hoc Fisher’s Exact tests to identify which specific levels differed significantly, using a Bonferroni-corrected alpha level of 0.017 for these three comparisons. For these focused tests, we obtained exact p -values directly via SPSS’s METHOD=EXACT procedure, a method recommended to ensure the reliability of findings when analyzing contingency tables with sparse data (Agresti, 1992). We reported Cramer’s V as the effect size for the initial omnibus tests.

Table 1 Gender distribution by occupational domain and representation type

Domain group	Gender	<i>N</i>	% within domain category
<i>Combined (N=1,195)</i>			
Female-dominated occupational domains (FDOD)	M	89	21.1
	F	158	37.4
	N/GF	174	41.2
	U	1	0.2
	Subtotal	422	100.0
Male-dominated occupational domains (MDOD)	M	166	58.5
	F	47	16.5
	N/GF	65	22.9
	U	6	2.1
	Subtotal	284	100.0
Other domains	M	40	32.0
	F	34	27.2
	N/GF	46	36.8
	U	5	4.0
	Subtotal	125	100.0
Domain not specified	M	108	29.7
	F	77	21.2
	N/GF	168	46.2
	U	11	3.2
	Subtotal	364	100.0
<i>Text (N=959)</i>			
Female-dominated occupational domains (FDOD)	M	61	18.0
	F	104	30.7
	N/GF	174	51.3
	Subtotal	339	100.0
Male-dominated occupational domains (MDOD)	M	124	55.1
	F	36	16.0
	N/GF	65	28.9
	Subtotal	225	100.0
Other domains	M	20	24.4
	F	16	19.5
	N/GF	46	56.1
	Subtotal	82	100.0
Domain not specified	M	76	24.3
	F	59	18.8
	N/GF	168	53.7
	U	10	3.2
	Subtotal	313	100.0
<i>Image (N=236)</i>			
Female-dominated occupational domains (FDOD)	M	28	33.7
	F	54	65.1
	U	1	1.2
	Subtotal	83	100.0
Male-dominated occupational domains (MDOD)	M	42	71.2
	F	11	18.6
	U	6	10.2

Table 1 (continued)

Domain group	Gender	<i>N</i>	% within domain category
Other domains	Subtotal	59	100.0
	M	20	46.5
	F	18	41.9
	U	5	11.6
	Subtotal	43	100.0
Domain not specified	M	32	62.7
	F	18	35.3
	U	1	2.0
	Subtotal	51	100.0

M male, *F* female, *N/GF* neutral/gender-fair, *U* unassignable, *FDOD* female-dominated occupational domains (HEED+services), *MDOD* male-dominated occupational domains (STEM+skilled trades)

Fisher-Freeman-Halton exact tests: combined data, $p < .001$, Cramer's $V = 0.20$; text $p < .001$, Cramer's $V = 0.21$; images $p < .001$, Cramer's $V = 0.29$

For focused inferential tests of H2a/H2b (Male/Female in FDOD/MDOD), see the Results section

4 Results

This section is organized into two main parts. First, in the General Descriptive Findings section, we present the distribution of neutral/gender-fair language, occupational portrayals outside our main analytical categories, and overall gender distributions across all six occupational domains. Second, in the Inferential Analyses section, we describe the results of testing our hypotheses. We analyzed 1,195 occupational portrayals from 19 textbooks, with 959 textual and 236 visual representations. All analyses are presented first for the combined dataset, followed by analyses of the textual and visual representations. Tables 1 and 2 present descriptive frequencies and percentages for horizontal and vertical segregation analyses. Comprehensive frequency data for specific occupational domains are provided in Online Appendix B, and detailed data on vertical segregation levels are presented in Online Appendix C.

4.1 General descriptive findings

Of the 1,195 occupational portrayals in the combined dataset, 719 (60.2%) were explicitly coded as male or female. The remaining portrayals used either neutral or gender-fair language forms (37.9%, $n=453$), a category applicable only to text, or had an unassignable gender (1.9%, $n=23$).

This distribution varied by modality. Among the 959 textual representations, 496 (51.7%) were explicitly gendered, while a substantial portion used neutral or gender-fair language (47.2%, $n=453$). In contrast, image representations ($N=236$) could only be coded based on visual cues of gender. Of these, 223 (94.5%) characters were coded with a clearly identifiable gender (male or female). The remaining 13 characters (5.5%) were coded as unassignable because the visual information was ambiguous (e.g., distant figures, uniforms obscured by other objects, or stylized, non-detailed drawings).

Beyond the primary female-dominated occupational domain (FDOD) and male-dominated occupational domain (MDOD) categories central to our hypotheses, 125

Table 2 Gender distribution by vertical segregation level, domain, and representation type

Domain Category	Gender	Segregation: high	Segregation: medium	Segregation: low	Exact Test <i>p</i> -value	Cramer's V
		<i>N</i> (%)	<i>N</i> (%)	<i>N</i> (%)	<i>p</i>	
<i>Combined</i> (Total <i>N</i> =1,195)						
Female-dominated occupational domains (FDOD)	M	5 (38.5)	66 (44.6)	17 (21.0)	0.001	0.23
	F	8 (61.5)	82 (55.4)	64 (79.0)		
	Subtotal	13	148	81		
Male-dominated occupational domains (MDOD)	M	26 (61.9)	119 (79.9)	21 (95.5)	0.006	0.22
	F	16 (38.1)	30 (20.1)	1 (4.5)		
	Subtotal	42	149	22		
<i>Text</i> (Total <i>N</i> =959)						
Female-dominated occupational domains (FDOD)	M	4 (40.0)	46 (43.8)	10 (21.3)	0.026	0.21
	F	6 (60.0)	59 (56.2)	37 (78.7)		
	Subtotal	10	105	47		
Male-dominated occupational domains (MDOD)	M	25 (62.5)	82 (79.6)	17 (100.0)	0.004	0.25
	F	15 (37.5)	21 (20.4)	0 (0.0)		
	Subtotal	40	103	17		
<i>Image</i> (Total <i>N</i> =236)						
Female-dominated occupational domains (FDOD)	M	1 (33.3)	20 (46.5)	7 (20.6)	0.053	0.27
	F	2 (66.7)	23 (53.5)	27 (79.4)		
	Subtotal	3	43	34		
Male-dominated occupational domains (MDOD)	M	1 (50.0)	37 (80.4)	4 (80.0)	0.558	0.14
	F	1 (50.0)	9 (19.6)	1 (20.0)		
	Subtotal	2	46	5		

Percentages calculated within segregation levels

M male, *F* female, *FDOD* female-dominated occupational domains (HEED+services), *MDOD* male-dominated occupational domains (STEM+skilled trades)

Fisher-Freeman-Halton exact test *p*-values and Cramer's *V* shown

portrayals (10.5%) in the combined dataset depicted occupations assigned to the category “other domains” (e.g., athletes, farmers), comprising men ($n=40$), women ($n=34$), neutral/gender-fair ($n=46$), and unassignable ($n=5$) characters. This category contained 82 textual and 43 visual portrayals. In the combined dataset, 364 portrayals (30.5%) could not be assigned to specific occupational domains, comprising 313 (32.6%) textual and 51 (21.6%) visual representations.

Omnibus Fisher-Freeman-Halton exact tests examining all six occupational categories (HEED, STEM, skilled trades, services, other, unspecified) revealed significant differences in the gender distribution in the combined data ($p < .001$), text (p

<.001), and images ($p <.001$), indicating systematic gender differences across all occupational categories (see Online Appendix B for details).

4.2 Inferential analyses

4.2.1 Hypothesis 1: Women are depicted less frequently than men in occupational roles

In the combined sample, 719 characters were explicitly coded as either male or female. As hypothesized, men (56.1%, $n=403$) were depicted significantly more frequently than women (43.9%, $n=316$), $\chi^2(1, N=719)=10.53, p=.001$. This difference was mainly driven by differences in textual representations ($N=496$), where men (56.7%, $n=281$) appeared significantly more often than women (43.3%, $n=215$), $\chi^2(1, N=496)=8.78, p=.003$. In contrast, visual representations ($N=223$) showed no significant difference in the depiction of men (54.7%, $n=122$) and women (45.3%, $n=101$), $\chi^2(1, N=223)=1.98, p=.160$.

4.2.2 Hypothesis 2: Women are depicted more frequently within female-dominated occupational domains (HEED and services) and less frequently within male-dominated occupational domains (STEM and skilled trades)

To test the hypothesis concerning horizontal segregation, Fisher's exact tests were conducted on 2×2 contingency tables (Gender [Male/Female] $\times$ Domain Type [FDOD/MDOD]). As shown in Table 1, the analyses revealed a strong, significant association between gender and domain type across all datasets.

For the combined data set ($N=460$), the association was significant (Fisher's Exact $p <.001$, Cramer's $V = 0.420$). Consistent with the hypothesis, women were more likely to appear in female-dominated occupational domains (FDODs), where they constituted 64.0% of characters ($n=158$), compared to 36.0% men ($n=89$). In contrast, women were less likely to appear in male-dominated occupational domains (MDODs), where they comprised only 22.1% of characters ($n=47$), compared to 77.9% of men ($n=166$).

A similar pattern emerged for textual representation ($N=325$; Fisher's Exact $p <.001$, Cramer's $V = 0.409$). Within female-dominated occupational domains (FDODs), women ($n=104$) were more frequently represented than men (37.0%, $n=61$), comprising 63.0% of the total. Within male-dominated occupational domains (MDODs), women comprised only 22.5% ($n=36$) of the characters, compared to 77.5% male characters ($n=124$).

For visual representations, the gender differences were even more pronounced ($N=135$; Fisher's Exact $p <.001$, Cramer's $V = 0.441$). Women constituted 65.9% ($n=54$) of characters in female-dominated occupational domains (FDODs) compared to 34.1% of male characters ($n=28$), but only 20.8% ($n=11$) of characters in male-dominated occupational domains (MDODs), where men constituted 79.2% ($n=42$). Therefore, H2 was fully supported across all data sets.

4.2.3 Hypothesis 3a: In female-dominated occupational domains (HEED and services), men are disproportionately represented in high-level occupational roles, while women are disproportionately represented in low- and medium-level occupational roles

To investigate whether gender distribution across hierarchical levels was disproportionate, we conducted Fisher-Freeman-Halton exact tests on 2×3 contingency tables (Gender [Male/Female] $\times$ Segregation Level [High/Medium/Low]), stratified by domain type. Significant omnibus tests were followed by pairwise post-hoc Fisher's Exact tests with a Bonferroni-corrected alpha of $p < .017$.

The analysis of the combined dataset for female-dominated occupational domains (FDODs; $N=242$) revealed a significant overall association between gender and hierarchical level ($p = .001$, Cramer's $V = 0.228$). Post hoc pairwise comparisons showed that this was driven by a significant difference between the medium and low levels (Fisher's Exact Test, $p < .001$). No significant differences were found between the high and medium levels ($p = .776$) or the high and low levels ($p = .175$). At the high level, women comprised 61.5% ($n=8$) of the characters, and men comprised 38.5% ($n=5$). At the medium level, women comprised 55.4% ($n=82$) and men 44.6% ($n=66$). At the low level, women comprised 79.0% ($n=64$) and men 21.0% ($n=17$).

For textual representations ($N=162$), the overall association between gender and hierarchical level was also significant ($p = .026$, Cramer's $V = 0.209$). Post-hoc pairwise comparisons revealed a significant difference in the gender distribution between the medium and low levels (Fisher's Exact $p = .010$), but not between the high and medium ($p = 1.000$) or high and low levels ($p = .240$). At the high level, women constituted 60.0% ($n=6$) of the characters, and men constituted 40.0% ($n=4$). At the medium level, women comprised 56.2% ($n=59$) and men 43.8% ($n=46$). At the low level, women comprised 78.7% ($n=37$) and men 21.3% ($n=10$).

For image representations ($N=80$), the overall association between gender and hierarchical level was not statistically significant ($p = .053$, Cramer's $V = 0.265$). Consistent with this, subsequent post-hoc pairwise comparisons found no significant differences between the high and medium levels (Fisher's Exact $p = 1.000$), the high and low levels ($p = .530$), or the medium and low levels ($p = .030$). At the high level, women represented 66.7% ($n=2$) of the characters, and men represented 33.3% ($n=1$). At the medium level, women comprised 53.5% ($n=23$) and men 46.5% ($n=20$). At the low level, women comprised 79.4% ($n=27$) and men 20.6% ($n=7$).

Based on these findings, H3a was only partially supported in the combined and textual data and not supported in the images. For the text data, a significant pattern of vertical segregation was found. However, only the prediction of women's disproportionate representation at low levels was confirmed. The hypotheses for women at medium levels and for men at high levels were not supported by the data.

4.2.4 Hypothesis 3b: In male-dominated occupational domains (STEM and skilled trades), men are disproportionately represented at all occupational levels (Low, medium, and high)

The analysis of the combined dataset for male-dominated occupational domains (MDODs; $N=213$) showed a significant overall association between gender and hierarchical level ($p=.006$, Cramer's $V=0.222$). Post hoc pairwise comparisons indicated that this was driven by a significant difference between the high and low levels (Fisher's Exact Test, $p=.003$). The comparisons between the high and medium levels ($p=.024$) and the medium and low levels ($p=.133$) were not statistically significant. At the high level, men comprised 61.9% ($n=26$) of characters and women 38.1% ($n=16$). At the medium level, men comprised 79.9% ($n=119$) and women 20.1% ($n=30$). At the low level, men comprised 95.5% ($n=21$) and women 4.5% ($n=1$).

For textual representations ($N=160$), the overall association between gender and hierarchical level was also significant ($p=.004$, Cramer's $V=0.254$). The post-hoc comparison between the high and low levels was significant (Fisher's Exact $p=.002$), while the comparisons between the high and medium levels ($p=.052$) and medium and low levels ($p=.041$) were not significant. At the high level, men constituted 62.5% ($n=25$) of characters and women 37.5% ($n=15$). At the medium level, men comprised 79.6% ($n=82$) and women 20.4% ($n=21$). At the low level, men comprised 100.0% ($n=17$) of characters, with no women depicted ($n=0$).

For image representations ($N=53$), no significant overall association was found between gender and hierarchical level ($p=.558$, Cramer's $V=0.143$). Consistent with this, none of the post-hoc pairwise comparisons reached statistical significance: high vs. medium ($p=.377$), high vs. low ($p=1.000$), and medium vs. low ($p=1.000$). At the high level, representation was equal, with one man (50.0%) and one woman (50.0%). At the medium level, men comprised 80.4% ($n=37$) of characters and women 19.6% ($n=9$). At the low level, men comprised 80.0% ($n=4$) and women 20.0% ($n=1$).

The findings also provided only partial support for H3b in the combined and textual data, but not in the visual data. In textual depictions, a significant pattern of vertical segregation was found. However, the hypothesis that men would be disproportionately represented at all three levels was not fully confirmed. The claim was statistically supported only for the low level, where men's representation was highest, but not for the medium or high levels. Therefore, while women descriptively outnumbered men at all levels in the text, the hypothesis of disproportionate overrepresentation was only met at the lowest level.

5 Discussion

This study examined general, horizontal, and vertical occupational gender segregation in textual and visual representations in German occupational orientation textbooks. The results provide evidence that textbooks reinforce traditional gender stereotypes. Three key findings emerged: First, women were generally significantly underrepresented in occupational roles, an effect driven by textual portrayals. Second, strong horizontal segregation was evident across both textual and visual representations,

with women overrepresented in female-dominated occupational domains (FDODs) and men overrepresented in male-dominated occupational domains (MDODs). Our results are comparable to those of the German labor market distributions (Bundesagentur für Arbeit, 2024). For instance, the gender distribution in our sample within FDODs (64% female) and MDODs (22% female) is strikingly similar to workforce statistics. This suggests that the textbooks we investigated function less as tools for expanding possibilities but instead mirror the existing segregation status quo. This occurs despite substantial use of gender-neutral language (38% of all portrayals), indicating that linguistic inclusivity alone (Sczesny et al., 2016) is insufficient to counteract deeply entrenched occupational stereotypes. Third, our analyses revealed that while horizontal segregation is consistently observed across both text and images, vertical segregation occurs only in textual representations. For both FDODs and MDODs, a significant pattern of vertical segregation was observed, with women being overrepresented at lower hierarchical levels in FDODs and men being overrepresented at all hierarchical levels in MDODs.

Our findings regarding the overall underrepresentation of women (H1) and the pronounced horizontal segregation (H2) align with a long history of textbook research that identifies educational materials as carriers of traditional gender roles (Moser, 2016; Ott, 2021). However, our study provides three crucial extensions. First, by systematically employing contemporary occupational classifications (FDOD, including HEED occupations and services, and MDOD, including STEM occupations and skilled trades; Blackburn et al., 2014; Croft et al., 2015; Fayer et al., 2017), our study offers a more comprehensive and current picture than earlier studies that relied on broader, less systematic categories (Finsterwald & Ziegler, 2007; Lindner & Luke-sch, 1994; Ott, 2017).

Second, we applied this classification to systematically compare gender occupational segregation across textual and visual representations. This allowed us to investigate not only whether segregation exists in these specific domains but also how it manifests across different modalities. While prior studies have examined both modalities (Strahl et al., 2014), our study also focuses on horizontal and vertical segregation, which yielded an interesting distinction: horizontal gender segregation was comparable across textual and visual representations, whereas the overall underrepresentation of women and the patterns of vertical segregation were primarily observed in textual representations. Our study reveals that different forms of occupational gender stereotypes manifest differently across representational modes; a methodological insight that single-modality studies (Finsterwald & Ziegler, 2007; Kerkhoven et al., 2016; Lee, 2014) cannot capture.

Third, and most critically, our study is the first to investigate gender distributions in specialized career orientation textbooks. While general and horizontal gender segregation has been found in general-subject textbooks ([blinded for review]) and other educational materials (Evans & Davies, 2000; Wharton, 2005), its presence in textbooks with an explicit curricular mandate to broaden students' career horizons (Draaisma et al., 2018; Guichard, 2001; ISB, 2025) is particularly concerning.

Our findings regarding vertical segregation (H3a and H3b) reveal a more nuanced picture than documented in previous textbook research (Finsterwald & Ziegler, 2007; Guichot-Reina & La Torre-Sierra, 2023). They are domain-specific and modality-

dependent, thus challenging simplified approaches to investigating vertical gender segregation in textbook research. We found no significant differences in gender representations across hierarchical levels in visual representations. This modality-specific finding suggests that images may not effectively convey hierarchical relationships without accompanying textual cues and may thus lead to an incomplete understanding. Our analyses of textual representations partially supported our hypothesis for female-dominated domains (H3a) and fully supported our hypothesis for male-dominated domains (H3b).

Within female-dominated occupational domains (FDODs), we did not find evidence for a ‘glass escalator’ effect, the phenomenon where men in female-typed fields experience accelerated advancement into leadership positions (Williams, 1992, 2013). Instead of the hypothesized overrepresentation of men at the highest hierarchy level, our analysis revealed the opposite finding: a disproportionate concentration of female characters at the lowest hierarchical level, constituting 78.7% of characters at that level. This finding reflects a ‘sticky floor’ (Berheide, 1992) effect: While textbooks portray women across all levels in these FDODs, they disproportionately anchor them in entry-level positions. Within male-dominated occupational domains (MDODs), textual representations revealed a systematic male dominance, although not entirely as hypothesized. While men outnumbered women at all three hierarchical levels, the statistically significant pattern was driven by the complete male domination at the lowest level, where no female characters were depicted.

These findings diverge from both our hypotheses and real-world labor market data in meaningful ways. The absence of the predicted glass escalator effect in FDODs contradicts documented distributions where men in female-dominated domains often advance more rapidly than their female colleagues (ILO & World Health Organization, 2022; Puzio & Valshtein, 2022). Similarly, the complete exclusion of women from entry-level positions in MDODs misrepresents the realities of the labor market. Their low representation at the middle and high hierarchy levels may align with previous research (Guichot-Reina & La Torre-Sierra, 2023; Ott, 2017), however, it misrepresents the German situation, where women, especially in technical occupations, show high advancement rates (Vicari et al., 2023). The underrepresentation of female characters in MDODs in occupational orientation textbooks conveys a clear message that technical and skilled trade careers are not suitable for girls; a perception empirically documented among female students by Lindner and Makarova (2024).

The contrasting distribution between domains, with women concentrated at lower levels in FDODs while men completely dominate MDODs, may reflect a form of selective progressiveness by textbook authors and publishers. This creates an illusion of gender equity by showcasing female presence within ‘acceptable’ feminine domains while maintaining rigid boundaries in masculine domains. Such a portrayal could be more insidious than uniform underrepresentation, as it implicitly teaches students that female ambition is permissible only within traditionally prescribed limits (Sinclair & Carlsson, 2013).

5.1 Theoretical implications

Our findings have important theoretical implications, particularly in relation to Social Role Theory (Eagly & Wood, 2012) and Gottfredson's (2002) theory of career development. Social Role Theory posits that gender stereotypes arise from observing men and women in different social roles. Our results identify career orientation textbooks as a potentially important source of such observations for adolescents. By documenting strong horizontal and vertical segregation, our study demonstrates that these textbooks function as cultural artifacts that contain the very role-based cues that Social Role Theory identifies as foundational to stereotype formation. Furthermore, the modality-dependent nature of our findings, where, for instance, vertical segregation was significant only in text, suggests that these observations may be transmitted with varying intensity across different forms of representation. Building on this, Gottfredson's (2002) theory of Circumscription, Compromise, and Self-Creation provides insight into how the differences in gender representations constrain career development. During adolescence, students progressively eliminate career options perceived as incompatible with their gender identity (Korlat et al., 2022, 2023). Textbooks, like the ones we have investigated in our study, provide the type of information that contributes to this narrowing process. The pervasive gender occupational segregation found in our study may lead to girls forgoing choices and opportunities, irrespective of their actual interest or aptitude. The pervasive horizontal segregation and the contrasting picture of vertical segregation found in our study are particularly relevant here. For young women, the message is complex: the depiction of women at all hierarchical levels within FDODs may initially seem empowering. However, when contrasted with the absolute male dominance shown in MDODs, it may implicitly convey that female career advancement is permissible only within these traditionally feminine boundaries. This can lead to a form of circumscription where girls forgo choices in MDODs, regardless of their actual interests or aptitudes. For young men, the message is more straightforward. The depiction of male dominance across all hierarchical levels of MDODs reinforces the notion that these domains are their natural territory, potentially leading to inflated expectations of advancement (Eagly & Karau, 2002; Weisgram et al., 2011). This dual messaging likely leads to what Gottfredson terms "compromise," where students adjust their career aspirations to match those perceived as gender appropriate. Young women may internalize the message that MDODs are largely closed to them, while young men are encouraged to pursue them with confidence. Such early compromises, shaped by the stereotypical content of educational material, can have lasting effects on career trajectories and economic outcomes (Reskin & Bielby, 2005).

5.2 Practical implications

Our findings have practical implications for educational stakeholders. For educators, the results highlight the need for a critical approach to career orientation materials. Rather than using textbooks solely for the transfer of didactic expertise (Hansen, 2018), teachers can leverage the stereotypical representations we identified as a pedagogical tool. By making these biases an explicit topic of classroom discussion, edu-

cators can foster students' critical media literacy and encourage them to deconstruct gender stereotypes in the professional world (Kostas, 2023; Liu, 2006). Furthermore, teachers should actively supplement the curriculum with materials that provide counter-stereotypical role models to present a more balanced view of career possibilities (Olsson & Martiny, 2018).

For textbook authors and publishers, our study shows a need to develop more equitable materials. Based on our findings, this involves three key actions: (1) ensuring numerical parity of men and women, especially in text; (2) challenging horizontal segregation by including counter-stereotypical role models (e.g., women in STEM, men in HEED; Puzio & Valshtein, 2022); and (3) addressing vertical segregation, e.g., systematically portraying women in leadership positions across all domains. Implementing these changes would help transform textbooks from being passive mirrors of a segregated society to active tools for fostering inclusive career guidance.

5.3 Limitations and future research directions

This study provides insights into horizontal and vertical occupational gender segregation in German occupational orientation textbooks, particularly in relation to female-dominated (i.e., HEED and services) and male-dominated (i.e., STEM and skilled trades) occupational domains. Despite several important findings, several limitations must be considered.

First, we analyzed textbooks exclusively from vocational-oriented schools (*Mittelschule*). While we deliberately selected this track because it places the strongest emphasis on occupational orientation and practical career preparation, with students typically transitioning directly to vocational training or employment after graduation, this focus limits the generalizability of our findings. The occupational portrayals in vocational-track textbooks may emphasize different hierarchical levels than those in academic-track (Gymnasium) textbooks. While the academic track leads toward university education and potentially higher-status careers, the vocational track typically leads to apprenticeships or direct employment. The vocational track textbook might therefore underrepresent high-level positions that require a university education. Furthermore, as our sample is culturally and nationally specific, the findings may not be generalizable to textbooks in other countries with different educational systems and cultural norms regarding gender. Future research should therefore examine career representations across all three German educational pathways and conduct cross-cultural research to gain a better understanding of the generalizability of our findings.

Second, our finding that horizontal segregation is evident in both text and visual representation, while vertical segregation emerges primarily in textual representation, reveals important methodological considerations. This discrepancy likely reflects the inherent challenges of conveying hierarchical status in visual depictions compared to explicit textual titles and descriptions (Stanczak, 2007). Future research should develop more sophisticated visual analysis methods to capture subtle status indicators in textbook images (Good et al., 2010).

Third, our analysis excluded some aspects of Moser et al.'s (2013) coding system, such as activities and gender-fair language usage. The use or non-use of gender-fair language significantly impacts the construction of gender roles (Sczesny et al., 2016)

and occupational perceptions (Vervecken et al., 2015). As an integral component of textbook-related research, future research should examine the full range of different forms of gender-fair language within occupational representations in educational materials.

A fourth limitation is our study's reliance on a binary operationalization of gender. Our methodology was based on the predominantly binary grammatical gender of occupational terms in German. While this binary focus aligns with historical sociological frameworks that treat gender as a structural category for analyzing occupational segregation (Blackburn et al., 2002; Risman, 2004), we acknowledge that it does not capture the full spectrum of gender as understood in contemporary theory (Hyde et al., 2019; Schmader & Nater, 2025). Future research should therefore aim to develop methodologies to identify and analyze non-binary and gender-diverse representations in educational materials. Such work, as discussed in recent work (Cruz Neri et al., 2024; Koster et al., 2025), is crucial for providing a more complete and more inclusive picture of gender in textbooks.

Despite these limitations, this study advances the field by integrating sociological frameworks of horizontal and vertical occupational segregation with contemporary occupational classifications and theoretical perspectives on gender stereotypes within career orientation textbooks. To our knowledge, these research streams have not been systematically combined or investigated in relation to one another previously. Future research should extend its focus to the private and unpaid sphere of gender representations (Coltrane & Adams, 1997; Ferrant et al., 2014) in order to more fully capture the division between private and public/work spheres (Landes, 1995/2013; Pateman, 1983; Wischermann & Mueller, 2004), particularly in the context of gender, work, and social inequality (Jarvis, 2017) as represented in textbook knowledge.

6 Conclusion

This study's systematic examination of textual and visual gender representations in German occupational orientation textbooks reveals a pervasive occupational gender segregation. Across 1,195 portrayals, we found that women were underrepresented overall, overrepresented in female-dominated occupational domains, such as HEED and service occupations, and underrepresented in male-dominated occupational domains at all hierarchy levels. Instead of broadening the potential occupational possibilities for students, the investigated textbooks appear to perpetuate the very stereotypes that limit adolescents' aspirations. However, our findings also provide a constructive perspective for change. Creating equitable resources requires a conscious effort by authors and publishers to avoid stereotypical gender representation in textbooks. This involves, first, achieving numerical parity in the overall representation of men and women in occupational roles in textual and visual representation in textbooks. Second, horizontal segregation in gender representation in occupational roles should be avoided and could even be counteracted by showcasing disproportionately high numbers of counter-stereotypical role models (e.g., women in STEM, men in HEED; Puzio & Valshtein, 2022). Third, vertical segregation can be challenged by portraying women in positions of authority, responsibility, and leadership across all

occupational domains. Only through such systematic transformation can textbooks fulfill their potential to foster truly inclusive career guidance for all students.

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Declarations

Competing interests The authors declare no conflict of interest.

Ethical approval No human participants or animals are involved in this study, and no informed consent was required.

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