IHS Working Paper 46
April 2023

Gender Segregation in Vocational Education and Occupations in the Context of Digitalisation

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Title

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Abstract

Austria is one of the countries with persistently high gender segregation in combination with a high matching of training and occupations. In this context, we analyse how educational and occupational segregation interact in the male-dominated fields of science, technology, engineering, and mathematics (STEM) and in the female-dominated areas of education, health and welfare (EHW). We discuss how atypical education can reduce gender segregation in the labour market and whether automation risks affect women and men in STEM and EHW differently. Firstly, our analysis shows that educational segregation is heavily transmitted to the occupational system in this fields. Secondly, the results point to the potential of gender-atypical fields for reducing segregation but also to their limitations especially since we find a double mismatch for women in STEM. Based on findings from digitalisation and automation research, we find that women are overrepresented in STEM jobs focussing on manual routine tasks which are more likely to be automated than the jobs primarily performed by men. While EHW is less prone to automation in general, the distribution of tasks between men and women indicates vertical segregation despite EHW being a female-dominated sector.

Key words: gender segregation, occupational segregation, vocational education, STEM subjects, mismatch, digitalisation

Zusammenfassung

Österreich zählt zu den Ländern mit anhaltend hoher Geschlechtersegregation, gleichzeitig zeigt sich eine hohe Übereinstimmung zwischen fachspezifischen Berufsbildungsabschlüssen und Berufstätigkeit. Vor diesem Hintergrund wird die Frage untersucht: Wie interagieren das Berufsbildungssystem und die berufliche Segregation in zwei stark segregierten Bereichen des Arbeitsmarktes? Mit dem Fokus der Analyse auf die männerdominierten Bereiche Mathematik, Informations- und Kommunikationstechnologie, Naturwissenschaft und Technik (MINT) einerseits und die frauendominierten Bereiche Bildung, Gesundheit und Soziales (BGS) andererseits verfolgen wir das Ziel, Geschlechtersegregation auf einer konkreten inhaltlichen Ebene zu diskutieren. Unsere Analysen zeigen erstens, dass sich Bildungssegregation in hohem Ausmaß auf das Berufssystem überträgt. Die Ergebnisse zu Frauen in MINT und Männer in BGS verweisen zweitens auf ein gewisses Potential geschlechtsuntypischer Ausbildungen und Berufe in Richtung Abbau der Segregation, zugleich aber auch auf deren Grenzen insbesondere bei Frauen in MINT. Darauf aufbauend, und unter Bezugnahme auf bisherige Erkenntnisse aus der Digitalisierungsforschung, können

drittens Schlussfolgerungen zum zukünftigen Potential in STEM und EHW gezogen werden.

Schlagwörter: Geschlechtsspezifische Segregation; Berufliche Segregation, Berufsbildungssystem; Mint-Fächer, Mismatch, Digitalisierung

Inhaltsverzeichnis

1 Introduction

Despite the general increase in women's employment and educational attainment, occupational segregation in most high-income countries has not changed substantially since the 1970s. Compared to other countries, traditional gender roles are still very prevalent in Austria and lead to large gender differences in the areas of education and training as well as in related occupations (OECD 2015a). Empirical findings show that occupational segregation stays persistent and would even have increased since 1995 without beneficial changes of the occupational structure (Leitner and Dibiasi 2015, EIGE 2017, Fritsch 2018).

If gender-segregated labour markets reflect gender preferences, specialization and non-detrimental division of labour are not necessarily negative or undesirable and may even increase social wellbeing. However, horizontal gender segregation creates and perpetuates gender inequalities by reinforcing gender stereotypes, limiting employment opportunities and career prospects, and contributing to the lack of societal appreciation of female-dominated jobs. In Austria, one quarter of the gender pay gap can be explained by gender segregation (Geisberger and Glaser 2017). The gender segregation factor of the pay gap has even been growing over the last few years.

At the same time, Austria shows a high degree of matching between educational profile and occupation. The proportion of women and men immediately finding a job that matches their educational background once they enter the labour market is significantly higher than the EU average (EIGE 2017). One explanation for this is the great importance of apprenticeship[1] and its close link to the labour market. This high degree of correspondence between vocational education and training (VET) and occupations inclines a closer look at the interaction between educational and occupational segregation. In this paper, we will therefore look at how educational segregation affects occupational segregation in the two highly segregated areas STEM (science, technology, engineering, and mathematics) and EHW (education, health and welfare). Our second focus are measures encouraging gender-atypical training and education and their effectiveness in reducing occupational gender segregation. Thirdly, we explore how digitalisation and automation interact with occupational segregation in STEM and EHW.

The paper is structured as follows: In section 2, we give a short overview on previous research on occupational and educational segregation and digitalisation and

[1] In Austria, 37% of the population finished a dual education in the form of apprenticeship. This form of training mainly aims at young adults aged 14-16 when they have finished mandatory education. Dual training incorporates both practical training at a firm and theoretical education at vocational schools. Apprentices are employed but often receive a rather modest allowance instead of a full-time salary.

automation. In section 3, we introduce the data and methodologies used. Section 4 presents the empirical results of our analysis which are discussed in section 5. The conclusions (section 6) draw some policy implications.

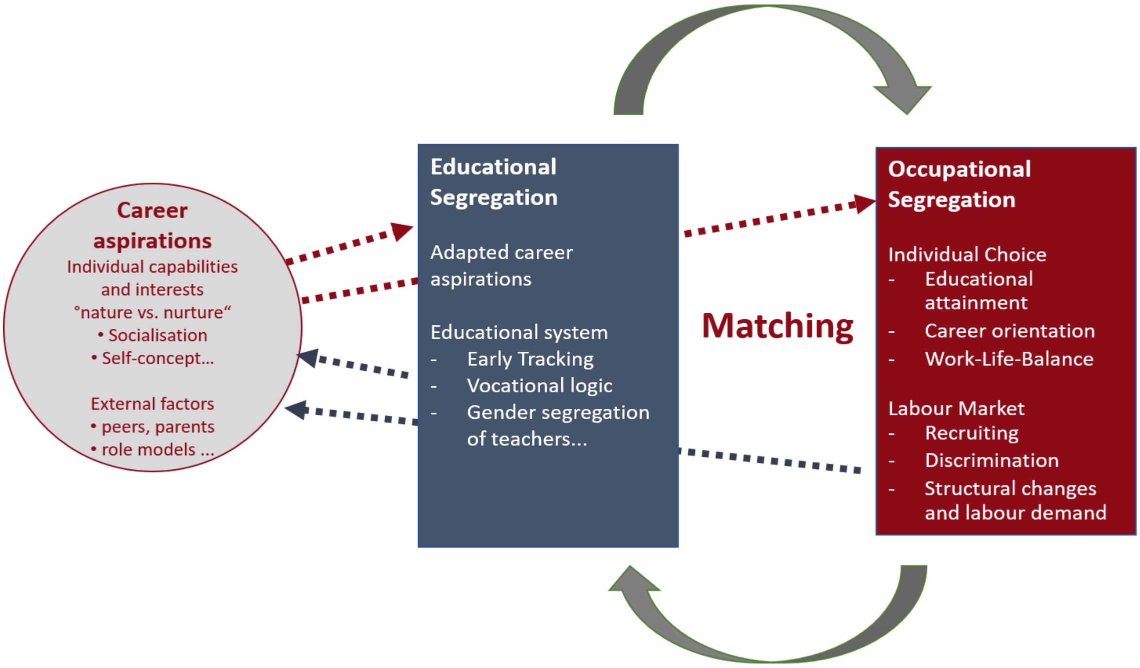
2 Segregation in education and occupation: explanations and narratives

Horizontal segregation is the 'concentration of women and men in different sectors and occupations' (EIGE 2020) and caused by the interaction of distinct factors which are emphasised differently depending on the context and focus of the explanation. While the economic theory of human capital highlights women's lower educational investments, gender segregation in sociological theories is determined by social structures and socialisation[1]. Whereas explanations on career aspirations are mostly focused on individual factors, realised educational and occupational decisions are more strongly influenced by previous decisions, individual resources and social constraints. As a result, adapted career aspirations and structural aspects of the educational and the occupational systems determine educational and occupational segregation. In the following, we will primarily refer to explanations relevant to the interaction of education and training with occupational segregation (Figure 1).

The educational decisions are closely related to career aspirations and, ideally, they match. Therefore, occupational segregation can be correlated with educational segregation via career aspirations and subsequent career choices. According to psychological approaches, individuals make career choices by comparing their personal skills and interests with various occupational profiles in order to find the ideal occupation for them. They thus implicitly assume a match (Schwiter et al. 2014) for which the ability self-concept plays a central role (Schöne and Stiensmeier-Pelster 2011). Studies dealing with the mathematical self-concept, for example, show that girls rate themselves significantly worse than boys (Blackwell et al. 2007, Lazarides and Ittel 2012, Bergmann et al. 2017). On average girls are less likely to feel that they are able to complete math-heavy or technical training and therefore exclude related occupations from the outset (Kahn and Ginther 2015). Moreover, the lack of role models for an atypical career supports the gender-typical career choice of girls and boys since role models are essential for young adults when they decide for a career. Both the occupational sphere – as perceived by young adults and teens – as well as the educational sphere lack atypical role models considering, e.g., the high gender segregation among teachers according to educational subjects (Bergmann et al. 2017).

[1] See Busch (2013) for a comprehensive overview of the most relevant theories.

Figure 1: Explanations and narratives for educational and occupational segregation



Source: Own figure.

Apart from the perception of one's own wishes and abilities, opportunity structures and implementation barriers are decisive for the realisation of career aspirations although certainly depending on the choice of school and career. The characteristics of an education system can produce and further intensify gender-specific differences in educational and career paths. For example, so-called early tracking systems with an early gender-specific focus on skills, school subjects, educational and occupational fields lead to greater segregation than more comprehensive educational pathways (Smyth and Steinmetz 2015; Scheeren et al. 2018). This can be explained by the early decision making as young people during early adolescence are particularly prone to identifying with gender stereotypes and role expectations (Gottfredson 2005; Schwiter et al. 2014). If – as in Austria[1] – the decision for an apprenticeship, school-based VET or a secondary general education is made systematically at the age of 13 to 15, this contributes to the stabilisation of occupational gender segregation.

As already mentioned above, the institutional characteristics of the educational system are decisive for educational segregation. Imdorf et al. (2015) show that certain

[1] In Austria boys and girls decide already at the age of 10 whether to enter an academic secondary school or a new secondary school. Although their prior decision *can* be revised at the age of 14, the school types have already created at least some type of social path dependency, meaning that at that time, the choice on whether to enter the vocational system or to continue with a more general education is made. The chosen path is seldom revised, but if so, often entails effort.

institutional arrangements such as those prevalent in Austria can significantly contribute to gender segregation in vocational education. According to Imdorf et al. education systems can be characterised along three educational logics: universalistic, vocational and academic. The universalistic logic is characterised by a high degree of permeability and the desire to enable the same education for all; thus, no early selection takes place. The situation is different within the academic logic where early selection is based on school performance and general education is more important than vocational training. In the vocational logic the focus is on occupation-specific skills and thus it acts selective according to career aspirations.

The Austrian system is following a strong vocational orientation in the education system (Kreimer et al. 2019). These are characterised by high occupational specificity and segmentation as well as a close linkage to the labour market. Consequently, vocational education and training heavily follows the requirements of the employment system. The close linkage between training and occupation, a characteristic typical for dual training systems, contributes to the perpetuation of gender-typical careers (Schwiter et al. 2014). Additionally, the Austrian education system urges young people to make an early decision, hence increasingly generating a gender-typical career choice and segregation. Since the universalistic logic is weak, decisions once made are difficult to revise and reorientation is costly. Together with the clear gender-specific allocation of the skills to be acquired to the professions practiced later, they reinforce a gender-typical choice of education and occupation.

In the so-called skill formation literature, the relationship between the increase in female employment and the matching of training and the labour market is described (Estévez-Abe 2006; Busemeyer and Trampusch 2012). Mayerl (2017) assigns Austria to the category of collective skill formation systems where labour market institutions commit themselves to inter-company standards and acquired skills should therefore be seamlessly transferred to other companies. In such systems, qualifications are very occupation-related and the central resource for workers in the matching process. Skill formation systems with a strong commitment to VET by companies, interest groups and the state usually show a high degree of gender segregation. On the one hand, this is because investments in women's vocational skills are perceived as riskier due to possible career interruptions. On the other hand, company-based forms of training tend to be located in male-dominated fields which reinforces horizontal segregation (ibid.).

Horizontal segregation is one of the causes for differences in reputation, career prospects and income between male- and female-dominated sectors (Kreimer 1999, Busch 2013, Leitner and Dibiasi 2015, EIGE 2017). In other words, horizontal segregation is intertwined with vertical segregation and therefore problematic from a gender equality perspective. Additionally, women’s underrepresentation in STEM comes with a loss of economic potential as gender segregation does not allow for full use of resources and slows down adaptation to changing labour market conditions (EIGE 2017). In the diversity management literature, heterogeneous teams (including gender-heterogeneous teams) have been shown to be more cognitively diverse and more productive and thus contribute to a higher overall productivity of a company (see e.g., Krell and Sieben 2007).

High productivity is often considered the ‘engine of growth’ (OECD 2015b). However, it might come at a cost: automation. Since Frey and Osborne’s (2017) findings on the probability of automation for different occupations in the United States[1], labour research has focused on the effects of digitalisation on occupations and the labour market but has not focused on gender. Similar studies were published for the labour markets and occupational structures of other countries (Bonin et al. 2015, Nedelkoska and Quintini 2018, Nagl et al. 2017 for Austria). These results, or more precisely the methodology used to obtain them, have been contested, in particular with regard to the fact that an occupation is too broad a category and thus may misrepresent how many jobs actually are at risk (e.g., Peetz and Murray 2019). In contrast to Frey and Osborne (2017), Arntz et al. (2017) find that only less than ten per cent of jobs are at risk when accounting for variation and heterogeneity of tasks within occupations.

Bock-Schappelwein et al. (2017) follow Autor et al. (2003) who categorise occupations with regard to their main tasks. Such tasks can be either non-routine and analytical, non-routine and interactive, non-routine and manual, cognitive routine or manual routine tasks.[2] Whereas from 1995 to 2015 the number of employees in manufacturing occupations with primarily manual (routine or non-routine) tasks decreased by more than a third, employees in manufacturing occupations involving mainly analytical and interactive non-routine tasks doubled and occupations focusing on cognitive routine tasks remained constant. Through a gender lens, manufacturing can be considered traditionally leaning towards male employment; thus, men overall worked less hours in 2015 than in 2008 (Bock-Schappelwein et al. 2017).

In the service sector, overall employment increased during the 1995-2015 period. Within routine tasks the number of cognitive jobs has been growing in particular within the service sector, e.g., in accounting, text processing, or diagnostics. In Austria, such jobs are characteristically performed by employees holding intermediate qualifications and

[1] Their results were frequently quoted and discussed. The study predicts that 47% of all occupations in the US are at high risk of automation, meaning that 47% of all occupations can be automated with a probability of 70% over a timespan of approximately one or two decades or even more.

[2] For instance, software development is an analytical non-routine job; care is an interactive non-routine job and carpentry is a manual non-routine job. (Land) surveying and surveillance are considered cognitive routine jobs, operating machines is considered a manual routine.

seem to be less prone to automation according to Bock-Schappelwein et al. (2017) in spite of job polarisation. Analytical and interactive non-routine tasks could also expand employment significantly – both in relative and absolute terms. Regardless, digital skills and competences are essential for developing and communicating creative and complex ideas. Consequently, cognitive and manual tasks will become less pertinent while digital literacy and skills like problem solving, teamwork and communications will gain importance (Law et al. 2018).

While most digitalisation and automation literature looks at the consequences of automation in a non-gendered way, Peetz and Murray (2019) take Frey and Osborne's (2017) findings as a starting point to include a gender perspective. Their conclusion suggests that female occupations have a slightly lower risk of automation compared to typically male occupations. This excludes the male-dominated ICT-sector which is unsurprisingly considered to have a low automation risk. Similarly, Pouliakas (2018) finds that automation risk is higher for low-skilled male workers.

With this paper, we want to gain deeper insights into the interaction between the segregation processes in the educational and occupational system. As we have shown above, there are a number of studies and explanatory approaches to both, but the interactions are still poorly researched to date. We therefore want to discuss three hypotheses with a particular focus on the highly segregated STEM and EHW sectors:

Firstly, occupational segregation is not only caused by processes in the labour market, but also to a great extent by processes in the educational system. Educational segregation results in occupational segregation, especially in countries with a dominant vocational logic in the education system.

Secondly, gender-atypical training and education has the potential to reduce occupational segregation since educational segregation results in occupational segregation.

Lastly, we know from the body of digitalisation literature that digitalisation does not affect all industries in the same way. Especially in the areas of STEM and EHW, digitalisation seems to have very different consequences, meaning that some STEM occupations have a higher automation risk than EHW occupations. Thus, the over-representation of women in the less risky EHW occupations may counterbalance negative effects of horizontal segregation in general.

In our analysis we concentrate on the two areas STEM (science, technology, engineering and mathematics) and EHW (education, health and welfare). Thereby we highlight areas that are in the focus of many labour market policy discourses in view of digitalisation, social and demographic changes and which are highly segregated with consequences on labour market outcomes. First of all, these areas are also relevant for a gender perspective: STEM occupations are often significantly better paid than EHW occupations. The low presence of women in STEM occupations thus contributes toward the gender pay gap (Thompson et al. 2020). Secondly, international competitiveness and sustainable development are essentially linked to technological innovations which could be increased through female participation (gender innovation gap, see Sexton and Ligler 2018). More women in STEM occupations would not only increase quantitative innovation capacity, but mixed-gender groups often produce more innovative solutions (Dye and Golnaraghi 2015). A higher participation of women in STEM occupations should be aimed for both for the benefit of women and overall economic performance.

The male-dominated STEM fields are contrasted with the female-dominated EHW fields. They are characterised by an increasing demand for labour caused by demographic developments such as the ageing of society. In contrast to STEM, however, there are no clear targets for reducing gender segregation: On the one hand it seems desirable that more men participate in EHW professions in order to turn them into integrated professions and thus to improve the image as well as the pay of the professions, whereas an increase of research on "caring masculinities" can be observed (Holtermann 2019; Gärtner & Scambor 2018). On the other hand, there is a risk that men will oust women from higher and well-paid positions. Accordingly, an improvement in working conditions and incomes is called for, independent of the reduction of segregation for these typically female occupations.

Gendered occupational transitions are increasing especially within the past five years. For women, the likelihood of changing into a gender-typed occupation is regaining relevance. However, the negative effects of these horizontal occupational movements on women's vertical position in the work environment need to be highlighted. Women transitioning into a gender typed occupation face a significant loss in occupational status, which increases additionally once women become mothers (Fritsch & Paulinger 2020). The dismantling of horizontal gender segregation therefore goes hand in hand with the overcoming of stereotypical gender roles and the diversification of educational pathways (Bundeskanzleramt 2019).

3 Data and methodology

In this paper, segregation is measured by the concentration on educational and occupational fields by gender and by women's share in STEM, EHW and other areas. Unlike other empirical approaches to measure segregation (e.g., distribution of women-dominated, men-dominated and mixed occupations, or segregation indices) this is not a statistical but a conceptional approach. We use a predefined and constant category of educational and occupational fields which allows for comparisons over time and across countries and is applicable to both the educational and the occupational system.[1]

As our database we use the Austrian Labour Force Survey (LFS). This survey is the only database for Austria that allows a nuanced analysis of occupations whilst providing information on educational attainment and socio-demographic characteristics. The analysis refers to women and men of prime working age, i.e., between 25 and 64 years of age, in order to cover the employable population that is very likely to have completed their education. In order to increase the sample size, two years are pooled, and trends are observed over the years 2005/06, 2011/12, 2016/17 and 2019/20. Although we do compare developments over time, it should be kept in mind that the Labour Force Survey does not provide panel data and all data used are cross-sectional.

Our definitions of STEM and EHW refer to EIGE (2017). With regard to education and training, we refer to the International Standard Classification of Education, ISCED-2011 and ISCED-F-2013 for the secondary and tertiary sectors (see Appendix A1). Occupations are classified according to ISCO-88 and ISCO-08 versions where both hierarchies and competences are considered (see Appendix A2). We slightly modify the EIGE framework to incorporate intermediate vocational qualifications in our framework.

In order to analyse the effects of educational on occupational segregation, we use a matching concept, i.e., we are measuring the proportion of women and men with formal educational achievements in the STEM and EHW fields who work in the occupation of their educational profile. We are particularly interested in the mismatch of education and occupation, i.e., when employees hold an EHW qualification but do not work in an EHW occupation for some reason. A mismatch can also appear from the inverse perspective, i.e., when somebody works in EHW but does not hold a corresponding qualification.

As a next step, we look at the gendered impact digitalisation has on the highly segregated EHW and STEM sectors by calculating the types of tasks women and men perform in these sectors. For this, we rely on Bock-Schappelwein et al. (2017) who adopt a task-based approach based on Autor et al. (2003) and operationalised by Spitz-Oener (2006) and Dengler et al. (2014). Task-based implies that the categorisation refers to the job task requirements2 rather than the occupation itself. Unlike Dengler et al. (2014), Bock-Schappelwein et al. (2017) ascribe a core task to each occupation which is consistent with earlier work by Bock-Schappelwein (2016). Consequently, each

[1] For a discussion of different approaches on the measurement of segregation see Bettio and Verashchagina (2009), Blackburn (2012) and Busch (2013), Burchell et al. 2014, EIGE 2017.

[2] Throughout the literature, these job task requirements follow official sources like Dictionary of Occupational Titles (Autor et al. 2003) or the BERUFENET categorisation by the German Federal Employment Agency (Dengler et. al 2014).

occupation is categorised as completing mainly analytical non-routine, interactive non-routine, manual non-routine, cognitive routine or manual routine tasks. Here, routine tasks can be accomplished by adhering to explicit rules (Autor et al. 2003), i.e., they can be automated easily.

4 Empirical results

In our analysis, we focus on STEM and EHW with which we cover about 40% of both educational qualifications and occupations. Within the educational qualifications, about 30% belong to STEM subjects, 11% to EHW subjects, 40% are VET qualifications in subjects outside STEM and EHW and 20% general education[1]. Among employees, the share of STEM occupations is smaller than their share of educational qualifications (22% compared to 30%), while the share of employees in EHW is larger (15% compared to 11%).

4.1 Segregation in education and occupations

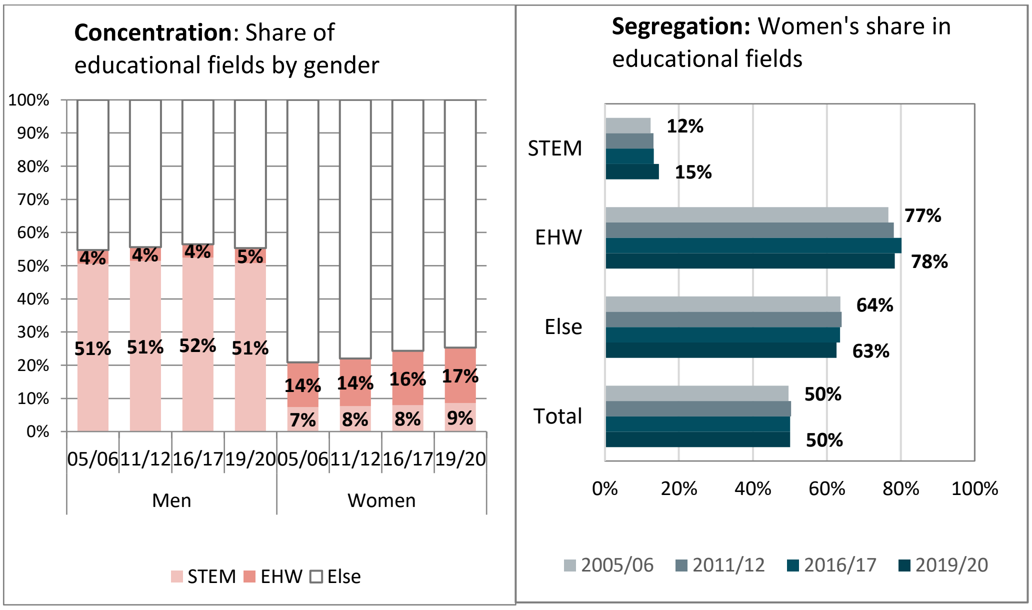
Similar to Germany or Switzerland, apprenticeship and school-based VET are dominant in the Austrian education system. By the highest formal educational attainment, nearly half of the Austrian population between 25 and 64 years of age have completed an apprenticeship or a VET intermediate school (see Appendix A3). Whereas dual education has lost importance in recent decades, intermediate and higher school-based VET has become more popular (BMBWF 2021). This shift can be attributed to structural changes towards a knowledge-based society, increasing demand for skilled labour and declining employer involvement in dual education. This development might potentially decrease overall gender segregation in education, mainly because intermediate education programmes are highly segregated due to their early career tracking (Leitner and Lassnigg 2018).

The results for educational attainment in Austria show that in 2019/20 more than half of men (51%) and only 9% of women graduated in STEM fields (Figure 2). This implies an immense concentration of men in STEM education. The number of women graduating in EHW is considerably lower than the number of men graduating in STEM: only 17% of women graduated in EHW fields. The largest share of women neither graduate in STEM nor in EHW, i.e., 75% of women received an education in fields outside STEM and EHW (see Appendix A4). To some extent, this can be explained by the narrow definition of EHW fields (see Appendix A2).

[1] For details on the levels of qualifications see Appendix A3.

As expected, women are disproportionately represented in EHW educational attainments, i.e., 78% of the EHW educated are women whilst only 22% are men in 2019/20. The opposite is true for STEM where women only account for 15% of graduates. Therefore, the STEM field is overall more segregated than the EHW field (Figure 2). As shown by the graphs, there are slight changes in the segregation from 2005/06 to 2019/20 with a slow but continuous increase of women's share in STEM and more stability or small fluctuations in EHW.

Figure 2: Concentration and segregation in formal qualifications (2005/06 -2019/20)



Source: LFS, IHS calculations.

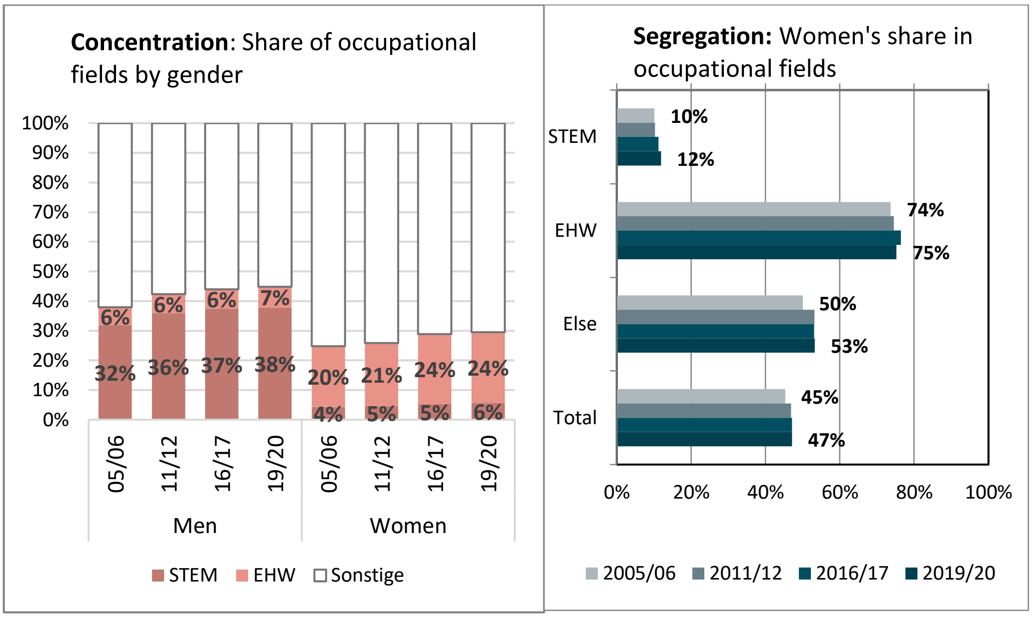
In comparison with other EU-countries, gender segregation in STEM degrees is roughly in line with the EU average in secondary education. However, if we focus on tertiary education, Austria performs worse than average with only a quarter of degrees being held by women. The share of men with EHW degrees is comparatively higher than in most EU-countries (EIGE 2017, p. 90). Women have disproportionately benefitted from educational expansion. However, gender segregation has not changed greatly. Between 2005/06 and 2019/20, the share of STEM qualifications rose slightly (from 13% to 15%), while the share of EHW qualifications for men remained relatively the same.

In the occupational system, the structural changes in STEM and EHW are even more visible than in the educational system. The EHW sector is considerably influenced by the sectoral change towards a service society which is intensified by demographic changes, i.e., growing demand for care, and the expansion of education. In the STEM sector, digitalisation and automation have contributed to a strong dynamic among high-level specialists and the information and communication professions (Mesch 2015).

Accordingly, in the period from 2005/06 to 2019/20, both the share of STEM occupations (from 19% to 23%) and that of EHW occupations (from 13% to 15%) increased (for 2019/20 figures (see Appendix A5). The increase in employment in highly segregated occupations potentially increases segregation overall.

The occupational share of men and women in STEM and EHW, depicted in Figure 3, illustrates that men's concentration in STEM is less pronounced in the labour market than in qualifications (see Figure 2). In 2019/20, 38% of men were employed in STEM while 51% hold a STEM degree. Similarly, women's proportion (6%) in STEM occupations is just half of their share in degrees. By contrast, the share of men and women in EHW occupations is higher than their share in corresponding qualifications. Hence it is not surprising that the share of women is largest in EHW occupations, accounting for 75% of the EHW workforce, and lowest in STEM occupations with about 12%. In occupations that are neither STEM nor EHW, women make up more than half of the workforce (53%). As shown by Figure 3, occupational segregation between EHW and STEM fields is clearly evident in Austria and seems to have changed little between 2005/06 and 2019/20.

Figure 3: Occupational concentration and segregation (2005/06 to 2019/20)



Source: LFS, IHS calculations.

Additionally, we could not observe significant differences considering age which reflects the slow increase of the women's share. Of all 25- to 44-year-olds holding STEM qualifications, only 16% are women while 13% of 45- to 64-year-olds with STEM degrees are women (see Appendix A6). Both socialisation and discrimination still seem to reinforce traditional career and educational choices. Differences in segregation according to qualification levels demonstrate the institutional impact of the educational system. 22% of those with higher STEM qualifications (VET colleges and tertiary education) are women, but only 13% of those with intermediate qualifications (see Appendix A6).

Looking at occupational tasks in STEM and EHW in more detail, we can see some tendencies towards the risk of automation (Table 1). According to the categorisation of Bock-Schappelwein et al. (2017), STEM occupations display a higher share of manual and cognitive routine tasks which can be replaced by machines more easily. However, greater differences are within non-routine tasks: 73 % of all tasks in EHW occupations are analytical or interactive non-routine tasks whereas STEM occupations are more often characterised by manual routine tasks.

Table 1: Tasks in STEM and EHW occupations

	Women and Men		Men		Women	
	STEM	EHW	STEM	EHW	STEM	EHW
Analytical non-routine	28%	36%	25%	44%	48%	33%
Interactive non-routine	0%	37%	0%	32%	0%	39%
Manual non-routine	44%	16%	48%	10%	14%	18%
Cognitive routine	20%	12%	20%	15%	19%	10%
Manual routine	9%	0%	7%	0%	20%	0%

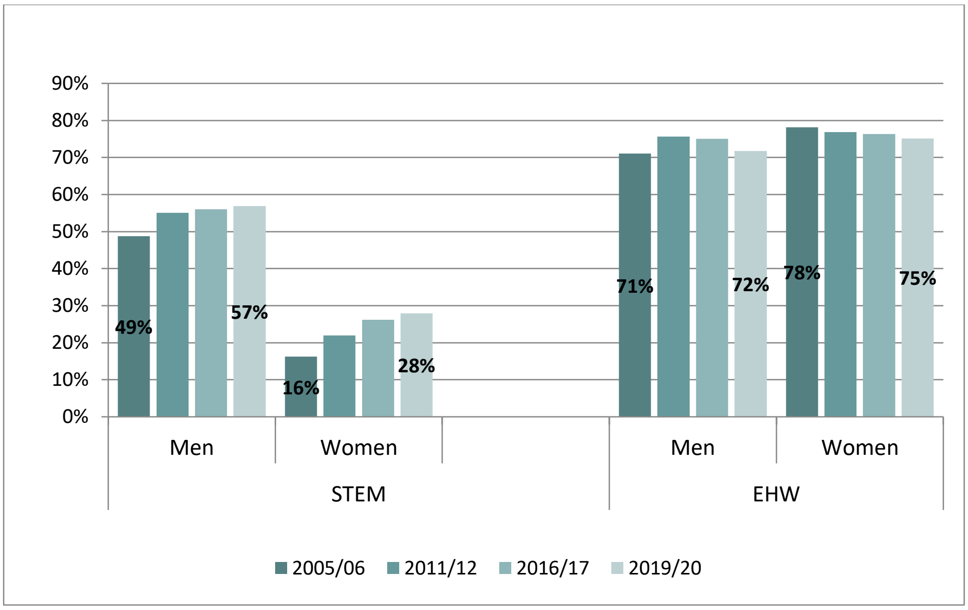
Source: Own calculations based on categories for tasks by Bock-Schappelwein et al. 2017.

We see further gender segregation within STEM and EHW tasks: In STEM, men are mostly working in manual non-routine tasks (48%) while women more often perform analytical non-routine tasks (48%) or manual routine tasks (20%). The gender differences in EHW are smaller but still evident: While women are stronger involved in interactive non-routine tasks, men more often perform analytical non-routines. This means that women in general seem to have a lower risk of automation through digitalisation, because manual tasks, both routine and non-routine tasks, can be replaced more easily. In EHW, the distribution of task types might indicate vertical segregation, i.e., men disproportionately performing jobs with analytical non-routine tasks could indicate that they are more likely to work in managing positions rather than jobs with interactive non-routine tasks such as nursing etc. In STEM, women seem to be particularly prone to automation risk since they are overrepresented in manual routine jobs.

4.2 Matching

In order to evaluate the effects of educational on occupational segregation, we look at the occupations of men and women with STEM and EHW qualifications in 2019/20. Note that the occupational matching indicator measures the share of men and women with a STEM and EHW qualification who work in a STEM or EHW occupation, respectively. As we can see in Figure 4, 57% of men with a STEM qualification work in a STEM occupation whereas this is the case for only 28% of women with a STEM qualification, i.e., women's matching in STEM is clearly lower. Nearly three-quarters of women with STEM qualifications work in a non-STEM sector. Interestingly, only one in five women who completed a secondary STEM-education works in STEM, while twice as many women with higher qualifications stay in STEM (see Appendix A7).

Figure 4: Matching of men and women with STEM and EHW qualifications (2005/6 to 2019/20 in %)



Source: LFS, IHS calculations.

Matching is higher in EHW for both men and women. More than 70% of those who hold qualifications in the field are employed there. On the one hand, this strong link can be favourable since men and women are encouraged to make use of their qualifications. On the other hand, strong specialisation – which is often the case for EHW professions – can complicate career changes, e.g., for teachers or medical professions. Once specialised, it is difficult to reverse such decisions, i.e., gender segregation in the educational sector may be reinforced on the labour market.

From 2005/06 to 2019/20, women's matching in STEM qualifications has increased by more than 10 percentage points. As a consequence, a rising share of women being trained in STEM implies an increasing share of women are utilising their training and working in STEM. Men's matching has also increased, albeit by a smaller margin. The rise in STEM qualifications is accompanied by an overall increasing share of STEM occupations. Although currently only 28% of women with a STEM qualification work in STEM, the increasing trend suggests that more women completing a STEM education can take advantage of their skills and education in an appropriate occupation (compared to 2005/06). However, matching for women in STEM is still rather low since they are the least likely to work in an occupation matching their education compared to three other groups discussed.

In EHW, matching remains rather constant over time, but slightly decreases for women.

4.3 Double mismatch

While the development of matching rates for women in STEM seems mildly encouraging, the overall mismatch of education and occupation in this field hardly supports any enthusiasm at all. We identify a double mismatch with respect to women holding STEM qualifications and women who work in STEM.

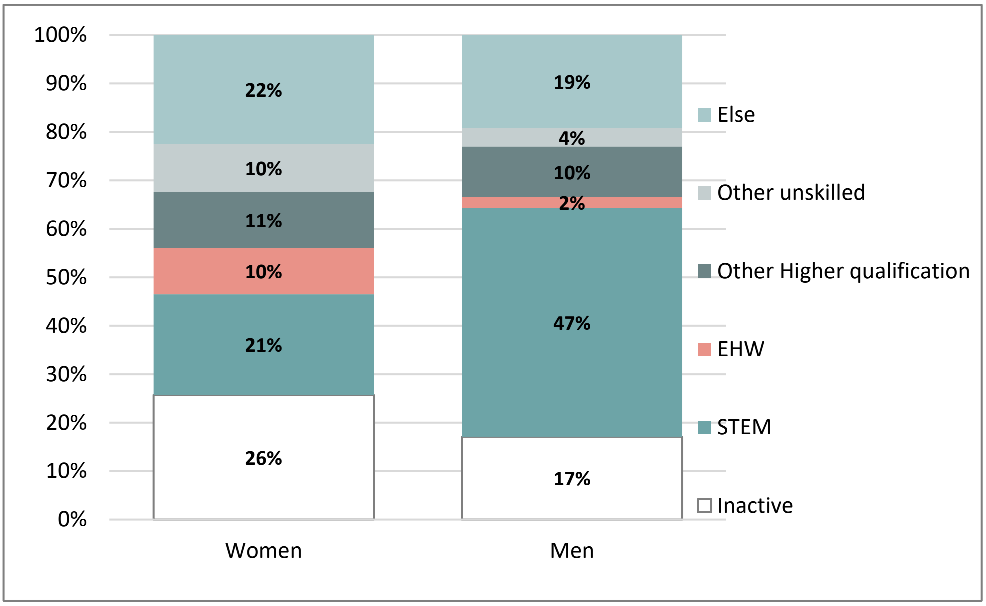
The first mismatch we identify refers to the matching discussed above, i.e., the actual occupations of women with STEM qualifications. The low matching rate for women with STEM qualifications inevitably evoke the question in which sectors they are employed or whether they have retreated from the labour force altogether. The mismatch of training and occupation can have many reasons like further training in a different field and re-training, promotion to a senior role not assigned to a specific sector or a temporary withdrawal from the labour market.

Compared to men, women with STEM qualifications tend to switch to other occupations more frequently (see Figure 5). 79% of STEM-trained women, but only 53% of their male peers leave the STEM sector when both unemployment and other reasons for labour market inactivity are considered.[1] Typically, the latter is more prevalent for women. More than a quarter – 26% – of women holding STEM qualifications are inactive, i.e., they are either unemployed or no longer part of the work force (see Appendix A8). Rather unsurprisingly, women leave STEM to work in EHW more frequently (10% compared to 2% of men). While the data do not reveal any about the specific occupations of workers with STEM qualifications, the level of employment according to the ISCO major groups is included. STEM-trained women are more likely to be employed

[1] Unlike section 4.2 (Figure 3 and Figure 4), the discussion in this section considers labour market inactivity and unemployment.

in elementary occupations in major group 9 according to the ISCO framework, more specifically, 10% work in unskilled jobs, i.e., occupations that do not require any training at all. Women with STEM qualifications, however, are as likely as men to work in occupations classified in major groups 1 to 3 which includes senior and managerial roles, academic, engineering, and non-technical occupations at the same level.

Figure 5: Employment of women and men with STEM qualifications in 2019/20



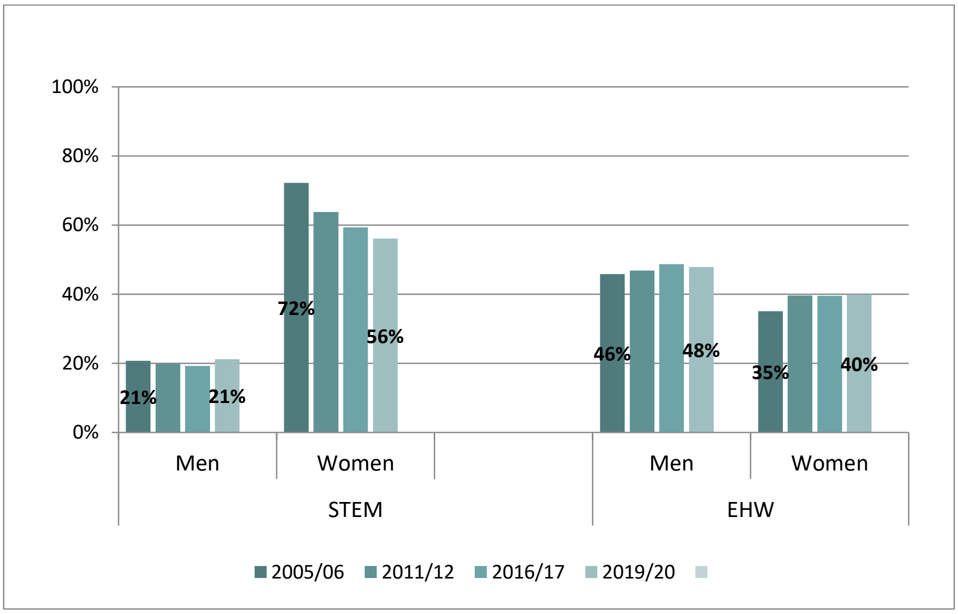
Source: LFS, IHS calculations.

Only about 30% of STEM-trained women thus seem to be able to utilise their qualification to further their career and only 21% make use of it within STEM. This is the first part of what we identify as a double mismatch.

The second part looks at workers from the perspective of their current occupation, i.e., we analyse employees in STEM/EHW occupations according to their qualification. In particular, we look at the share of employees in STEM and EHW which were trained correspondingly and hold qualifications in their field. Similar analyses can be found in the debate about mismatch and overqualification of workers (see e.g., Bock-Schappelwein and Huemer 2017) and in labour shortage discussions about the lack of qualified workers (see e.g. Fink et al. 2015).

In 2019/20, 56% of women employed in a STEM occupation did not hold a corresponding qualification whereas only 21% of men working in STEM were not trained accordingly (Figure 6). Not only, that women holding STEM qualifications do fail to utilise their training, most women working in STEM did not receive corresponding training. Additionally, 14% of women in STEM perform manual routine tasks which further supports our hypothesis that women in STEM are not trained in their field of work and therefore mainly work in jobs and occupations requiring a low level of skills and qualifications (see Table 1). This may not only perpetuate vertical gender segregation in STEM, but potentially also contributes to the gross gender pay gap within STEM – if women are mainly employed in low-skilled jobs and men are more likely to occupy supervisory roles, the latter are more likely to earn a higher income. Moreover, the second aspect of the double mismatch puts women's STEM jobs disproportionately at risk in the long run. Since manual routine tasks are more likely to be automated – and women disproportionately perform such tasks in STEM –, the lack of corresponding training and education might harm women's employment in STEM.

Figure 6: Mismatch of training and occupation for men and women in STEM and EHW (2005/6 to 2019/20, in %)



Source: LFS, IHS calculations.

In EHW, the gender-specific difference in the matching of training and occupation is smaller since 40% of women and 48% of men lacked corresponding training. Since 2005/6, the mismatch has slightly increased with a lower percentage of both men and women holding corresponding qualifications.

From 2005/6 to 2019/20, the STEM mismatch for women slightly declined which could be the consequence of initiatives encouraging women to take up STEM training, as e.g., FIT - Frauen in die Technik (Women for Engineering)[1]. However, it should be kept in mind that these numbers are cross-sectional and do not have a panel data character. Overall, this second part of the double mismatch is likely to contribute to the large income differences between genders in STEM occupations.

5 Discussion

We started our analysis with three hypotheses: Firstly, we expect to get results showing that educational segregation is transmitted to the occupational sector. Secondly, we expect to see positive trends towards reducing occupational segregation by atypical training and education, especially by women holding STEM qualifications. Thirdly, as digitalisation does not affect all occupations in the same way, we expect that women in STEM and in EHW are exposed to different risks of digitalisation.

Our first hypothesis can be clearly confirmed: educational segregation results in occupational segregation. Our analyses are in line with the results put forward by EIGE (2017). High matching rates between VET and corresponding occupations are typical for countries with a strong vocational logic in the education system. Such high matching rates are economically desirable since they supposedly stand for an efficient use of skills and knowledge. However, the downside of high matching is the partial consolidation of horizontal segregation, i.e., men in STEM and women in EHW occupations. Interestingly, women's matching rates differ substantially depending on whether they were trained in STEM or EHW. Women's chances of finding an adequate job seem to be higher in EHW than in STEM.

The second hypothesis on the segregation-reducing potential of gender-atypical education and training can also be confirmed, but with clear limitations. There is potential, albeit small, to reduce segregation since the proportion of women in STEM occupations and the matching rate of women in STEM have increased. Although small, this can be regarded as undeniable success for initiatives supporting girls and women in STEM. But the share of men in EHW has hardly reduced segregation so far. Matching rates for men in EHW have increased slightly, but the proportion of men in EHW has even declined and the share of EHW occupations in men's employment is stagnating. Initiatives encouraging men to choose an EHW career have only been in place for short

[1] The FIT initiative (Frauen in die Technik – Women for Engineering) encourages girls to choose a technical or science higher education degree. FIT ambassadors – female university students at engineering and science faculties – visit schools in order to inform prospective university students about training and working in STEM (for Vienna, Lower Austria and Burgenland see https://www.fitwien.at). The Austrian Employment Service Agency (Arbeitsmarktservice – AMS) supports various initiatives encouraging women in STEM (see e.g., https://tinyurl.com/y3wmu5l8).

periods of time – which may be too short (and small) to make a difference so far and reduce segregation effectively.[1]

A closer look at our matching analyses reveals the limitations of the strategy to reduce segregation by choosing atypical career paths. Especially in STEM, women are shown to have considerable rates of mismatch as only a quarter of women with STEM qualifications work in a corresponding occupation. This rate of matching is lower than in all other sectors. The reasons for such a mismatch can be found in the transition from training to labour market as well as in the occupational system itself. The so-called revolving doors mechanism may be one of these factors explaining the low rate of women working in STEM professions. Revolving doors means that women who first work in traditionally male sectors return to more typically female occupations (Jacobs 1989, Kahn and Ginther 2017). Consequently, revolving doors prevent atypical career choices from significantly reducing gender segregation in the long run (Heintz et al. 1997).

For Austria, there is no direct evidence to suggest revolving doors, caused also by missing panel data. However, there are some hints indicating revolving doors: Although more women complete education and training in STEM, and although the matching rate in STEM has increased, there are still relatively few women working in STEM occupations – it seems that STEM-trained women leave STEM occupations or do not enter STEM professions at all. The mismatch analyses supports this indirect evidence, for instance by showing that one in ten STEM-trained women now works in EHW occupations (see Figure 5). In addition, the second mismatch result shows that women working in STEM have the lowest rates of matching training and occupation, i.e., they frequently work in STEM occupations without holding corresponding STEM qualifications.[2] Unfortunately, the available data do not allow for an in-depth analysis of the mismatch. We do, however, assume a contribution to the gender pay gap since women without corresponding training in STEM are likely to be paid lower wages despite STEM being a high-wage sector.

The reasons for revolving doors are diverse. On the one hand, Kahn and Ginther (2015) show that especially those female engineers who have or wish to have children tend to change careers. On the other hand, several studies demonstrate that women feel less at ease in traditionally male sectors and thus change careers more quickly (Glass et al. 2013, Hunt 2016). According to Goldin and Katz (2016), women prefer non-competitive

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[1] While FIT (a broad program encouraging girls and women for technical education) started in the 1990s, Austrian initiatives advertising broader career choices for boys and young men only began in 2008 (see https://www.boysday.at). Boys in Care was an initiative supported by the EU's Rights, Equality and Citizenship program and national departments and ministries. Aiming to encourage boys to work in EHW, it ran from April 2017 until September 2019 in Bulgaria, Germany, Italy, Lithuania, Austria and Slovenia (see https://boys-in-care.eu).

[2] Note that the data only reveal the highest formal qualification but do not consider skills acquired by on-the-job training and other forms of further training.

and socially rewarding occupations with a high percentage of female co-workers, subsequently choosing a career as a practical physician over a research career. Such individual decisions can be subject to discriminating limitations when, for instance, recent STEM graduates take longer to get a job if they are women (Minks 2001). Similarly, Busch (2013) concludes that social control prevails over work-life-balance issues as a reason for revolving doors in Germany since women still are considered less competent or even intrusive in sectors atypical for their gender.

With our third hypotheses we take into account processes that are caused by digitalisation. In the case of the female-dominated EHW area, gender segregation has some positive side-effects as these occupations have in general a lower risk to be automated since there are none or few routine and non-routine manual tasks in EHW occupations. For non-routine tasks, there are some gender differences (see Table 1) which could indicate vertical segregation within the occupations, but all non-routine tasks show lower risks of automation. The situation is slightly different in STEM: The tasks women perform seem to be polarised as they are disproportionally working in analytical non-routine tasks (48% of women compared to 25% of men) which are relatively unlikely to be automated; at the same time, they are disproportionally performing manual routine tasks (20% of women compared to 7% of men) with a rather high risk of automation and, consequently, job loss. This polarization trend in female employment in STEM should be taken into account when designing gender equality strategies for women in STEM.

6 Conclusion

What did we learn about the potential to reduce gender segregation by looking at the two highly segregated areas STEM and EHW?

Encouraging women to choose STEM training and occupations is still a useful strategy in order to reduce gender segregation and other inequalities in the labour market. Supporting women in occupations requiring highly qualified workers is of utmost importance since such jobs are thought to be less affected by digitalisation. To date, this has worked poorly for reasons such as revolving doors and working conditions leading to inadequate work-life-balances. A successful gender equality strategy should take into account the double mismatch analysis. It seems inefficient to encourage young girls to start education and training in STEM when they later see no possibilities to remain in STEM and prefer to work in unskilled jobs rather than STEM. Furthermore, higher female employment in STEM will fail to contribute to gender equality if these women do not have appropriate qualifications or if they perform manual routine tasks in STEM occupations with a high risk of automation. More research is needed: firstly, on women working in STEM without corresponding qualifications and, more importantly, on policies to help them acquire such qualifications; secondly, on revolving doors, accessibility for women and corresponding policies in order to establish women in high-skilled STEM occupations.

The male-dominated STEM fields are contrasted with the female-dominated EHW fields. They are characterised by an increasing demand for labour caused by demographic developments such as the ageing of society. While EHW jobs have experienced increased appreciation in times of crisis over the last few months in 2020, their working conditions and pay have hardly improved. In order to attract men, this would have to change drastically. Although encouraging men to go into EHW fields may seem a simple solution to gender segregation, an increased share of men could drive women out of the rather protected sector which is often appreciated by women who have reproductive and care responsibilities. Such policies could even make high-skilled and managerial positions less accessible to women. Within EHW, there seems to be an invisible division of labour: Men are more likely to perform analytical non-routine tasks whereas women are more often working in interactive non-routine task jobs. Although there is no definitive evidence, this division of tasks indicates that such processes of vertical segregation are already in place. Therefore, policies encouraging women to take on managerial positions in EHW are essential. This could include programmes to improve digital literacy or mentoring initiatives for potential female leaders. Such measures are paramount to hinder and reduce vertical segregation within a female-dominated sector.

7 Literature

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8 Appendix

Table A1: Definition of STEM and EHW educational fields

	ISCED 2011	ISCED-F 2013
STEM	4 Science, Mathematics and Computing 5 Engineering, Manufacturing and Construction	05 Natural science, Mathematics and Statistics 06 Information and Communication Technologies 07 Engineering, Manufacturing and Construction
EHW	14 Teacher Training and Education Science 7 Health and Welfare	01 Education 09 Health and Welfare

Categories oriented on EIGE (2017). The fields of education, measured with ISCED-categories, include both secondary vocational education levels (ISCED 35-45) and tertiary levels (ISCED 5-8).

Table A2: Definition of STEM and EHW Occupations

	ISCO 88	ISCO-08
STEM	21 Physical, Mathematical and Engineering Science Professionals 31 Physical and Engineering Science Associate Professionals 71 Extraction and Building Trades Workers 72 Metal, Machinery and Related Trades Workers 74 Other Craft and Related Trades Workers 81 Stationary-Plant and Related Operators 82 Machine Operators and Assemblers	21 Science and Engineering Professionals 25 Information and Communications Technology Professionals 31 Science and Engineering Associate Professionals 35 Information and Communication Technicians 71 Building and Related Trades Workers (excluding Electricians) 72 Metal, Machinery and Related Trades Workers 74 Electrical and Electronic Trades Workers 81 Stationary Plant and Machine Operators 82 Assemblers
EHW	22 Life Science and Health Professionals 23 Teaching Professionals 32 Life Science and Health Associate Professionals 33 Teaching Associate Professionals 513 Personal Care and Related Workers	22 Health Professionals 23 Teaching Professionals 32 Health Associate Professionals 53 Personal Care Workers

Categories oriented on EIGE (2017).

Table A3: Highest formal educational attainment (in %) in STEM and EHW (2019/20)

	Women and Men			Men			Women		
	STEM	EHW	Total	STEM	EHW	Total	STEM	EHW	Total
Apprenticeship/dual education	64.6	6.5	36.4	68.2	7.1	45.1	43.3	6.4	27.6
Intermediate vocational school	5.4	28.8	12.6	4.9	16.6	8.6	8.4	32.2	16.5
College for higher vocational education	13.6	8.1	11.0	13.2	4.0	10.8	15.7	9.2	11.3
University/Higher education	16.0	56.3	20.1	13.2	72.2	18.0	32.1	51.9	22.1
Other	0.4	0.2	20.0	0.4	0.2	17.5	0.4	0.3	22.5
Total	100	100	100	100	100	100	100	100	100

Source: Austrian Labour Force Survey ("Mikrozensus-Arbeitskräfteerhebung") 2019/20, Calculations: IHS.

Table A4: Concentration and Segregation of Highest Educational Degree by Disciplines

			Concentration (in %)			Women's Share (in %)
	Men	Women	Men	Women	Total	
STEM	1,297,890	221,739	50.7	8.7	29.7	14.6
05 Natural Science, Mathematics and Statistics	38,243	29,914	1.5	1.2	1.3	43.9
06 Information and Communication Technologies	41,949	1,1946	1.6	0.5	1.1	22.2
07 Engineering, Manufacturing and Construction	1,217,698	179,879	47.6	7.0	27.3	12.9
EHW	117,606	427,511	4.6	16.7	10.6	78.4
01 Education	46,017	181,164	1.8	7.1	4.4	79.7
09 Health and Welfare	71,589	246,347	2.8	9.6	6.2	77.5
Other Disciplines	1,142,696	1,913,460	44.7	74.7	59.7	62.6
Total	2,558,192	2,562,710	100	100	100	50

Educational attainments according to ISCED-F 2013.
Source: Austrian Labour Force Survey ("Mikrozensus-Arbeitskräfteerhebung") 2019/20, Calculations: IHS

Table A5: Concentration and Segregation of STEM and EHW Occupations (2019/20)

	Men	Women	Concentration (in %) Men	Women	Total	Segregation Women's Share (in %)
STEM-Occupations	776,663	104,806	37.9	5.7	22.7	11.9
21 Science and Engineering Professionals	91,844	32,128	4.5	1.8	3.2	25.9
25 Information and Comm. Techn Profess.	66,960	15,607	3.3	0.9	2.1	18.9
31 Science and Engineering Assoc.Profess.	165,817	17,253	8.1	0.9	4.7	9.4
35 Information and Comm. Technicians	26,515	4,516	1.3	0.2	0.8	14.6
71 Building and Rel. Trades Workers	156,906	3,779	7.7	0.2	4.1	2.4
72 Metal, Machinery, Rel. Trades Workers	144,133	8,210	7.0	0.4	3.9	5.4
74 Electrical,Electronic Trades Workers	66,823	2,378	3.3	0.1	1.8	3.4
81 Stationary Plant, Machine Operators	42,612	15,090	2.1	0.8	1.5	26.2
82 Assemblers	15,053	5,845	0.7	0.3	0.5	28.0
EHW-Occupations	143,352	434,503	7.0	23.8	14.9	75.2
22 Health Professionals	46,597	129,864	2.3	7.1	4.5	73.6
23 Teaching Professionals	60,032	148,457	2.9	8.1	5.4	71.2
32 Health Associate Professionals	21,575	44,955	1.1	2.5	1.7	67.6
53 Personal Care Workers	15,148	111,227	0.7	6.1	3.3	88.0
Other Occupations	1,130,934	1,288,057	55.1	70.5	62.4	53.2
Total	2,050,949	1,827,366	100	100	100	47.1

Occupational Categories by ISCO-08, Source: Austrian Labour Force Survey ("Mikrozensus-Arbeitskräfteerhebung") 2019/20, Calculations: IHS.

Table A6: Gender Share (in %) in STEM and EHW Occupations by Socioeconomic Characteristics

	STEM		EHW		Other	
	Women	Men	Women	Men	Women	Men
Age						
25-44 Years	16	84	79	21	61	39
45-64 Years	13	87	77	23	64	36
Education						
Apprenticeship and intermediate VET	13	87	86	14	63	37
Colleges and Tertiary Education	22	78	73	27	61	39
Migrant Background						
Without Migrant Background	13	87	78	22	64	36
Migrant Background	23	77	79	21	59	41
Total	15	85	78	22	63	37

Source: Austrian Labour Force Survey ("Mikrozensus Arbeitskräfteerhebung") 2019/20, Calculations: IHS.

Table A7: Difference between Education Groups in Women's Share (in %) in STEM, EHW and Other as well as Occupational Matching for Women (2019/20)

	Women's Share			Occupational Matching	
	STEM	EHW	Other	STEM	EHW
Apprenticeship and Intermediate VET	10.8	85.5	62.9	18.5	76.7
VET Colleges and Tertiary Education	23.6	74.5	61.8	37.2	74.3

Source: Austrian Labour Force Survey ("Mikrozensus Arbeitskräfteerhebung) 2019/20, Calculations: IHS.

Table A8: Share of Inactive and Unemployed Persons (in %) in STEM and EHW (2019/20)

	Inactive Persons				Inactive and Unemployed Persons			
	STEM	EHW	Other	Total	STEM	EHW	Other	Total
Women	21.6	17.0	27.7	25.4	25.7	18.7	31.3	28.7
Men	14.4	9.3	18.5	16.0	17.1	1.4	23.8	19.8

Source: Austrian Labour Force Survey (“Mikrozensus Arbeitskräfteerhebung) 2019/20, Calculations: IHS.