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Gender and choice: differentiating options in Swedish upper secondary STEM programmes

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ABSTRACT
The extensive reforms of Sweden’s education system during the last few decades have resulted in deregulation and individualization of schools. In upper secondary education, a distinct flexible course structure with multiple options was introduced in order to enhance school effectiveness and equity. This study departs in some of the previously outlined tensions in educational research between market interests and a ‘free choice discourse’ in relation to processes of differentiation. The purpose of this article is to investigate the ways gender patterns may be reproduced in relation to the emergence of multiple options and the re-organization of subject matters within Swedish upper secondary science, technology, engineering and mathematics (STEM) education. Our case addresses relations between discourses of choice and gender articulated in policy incentives, and large-scale enrolment patterns. Our results show how multiple options reproduce gender orders by 1) changing the system in accordance with a general market logic emphasizing ‘freedom of choice’, and 2) distinguishing predominantly gendered subject matters. Also, our results point to the importance of studying the STEM domain at a non-aggregated level to further understand the mechanisms behind gender gaps in STEM education.

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Critical analysis; Gender

Introduction
During the last decades, school market reforms have created an exhaustive deregulation of European school systems (e.g. Fjellman, Yang Hansen, and Beach 2018; Kosunen and Carrasco 2016; Ball 2010; Reay 2004; Ball, Bowe, and Gewirtz 1996). Recent studies of the Swedish school system have pointed in a similar direction, outlining an increasing tension between market interests and a ‘free choice discourse’, on the one hand, and an increasing differentiation between and within schools, on the other hand (e.g. Beach 2018; Dovemark et al. 2018; Yang Hansen and Gustafsson 2016). Furthermore, studies show that Swedish pupils are easily influenced by market discourses when choosing upper secondary education (Lidström, Holm, and Lundstrom 2014; Lund 2008) but also that the understanding of ‘freedom of choice’ tends to differ between boys and girls (Asp-Onsjö and Holm 2014). In this study, our
general aim is to deepen the contemporary knowledge about these relationships, focusing on how the organization of education in accordance with ideas of individual choice and flexible options risk-limiting boys’ and girls’ opportunities for future studies and employment.

Concurrent with the marketization of Swedish schools, a more flexible course structure was introduced in upper secondary education during the 1990s. This structure was to enable the introduction of multiple options, which in turn made it possible for schools to adjust curricula in relation to local labour market needs as well as for students to make individual choices within the broader framework of a particular programme (SMER 1994). Following the reform of 1994, the STEM (Science, Technology, Engineering, and Mathematics) domain within upper secondary school and more specifically the area of technology was politically targeted as a domain in which multiple options would improve gender equality (SMER 1997). Accordingly, the empirical objective of this study is to outline how the introduction of a flexible course structure in Swedish upper secondary education in 1994, particularly the policy emphasis regarding the structure of the STEM domain (SMER 1998), interacts with gender.

Thus, our aim is to investigate how gender relations in the upper secondary Natural Sciences and Technology programmes are affected by the emergence of a structure diversified by multiple options. By focusing the natural sciences and technology, we place our study within the wider context of STEM education. The reasons are threefold: First, the ongoing national and international research debate about the STEM area seems to concern transnational issues of welfare, economy, employability, but also gender balance and equity (e.g. Kanny, Sax, and Riggers-Piehl 2014; Smith and White 2011). Second, there seems to be a particular need for investigations of this area. Reports from Sweden illustrate concerns related to a growing need for more STEM-educated staff, but also worries about numbers of drop-outs and problems regarding gender balance (Statistics Sweden 2013). Third, the Swedish upper secondary Natural Sciences programme is strongly connected with academic degrees in engineering, science and medicine.

The gender gap in higher education STEM programmes is highly researched within different fields of study. For example economists, Aucejo and James (2016) argue that the gender gap in STEM college education in England partly can be explained by males being more sensitive to comparative differences between mathematical and verbal skills, than females (Aucejo and James 2016; cf. Wang, Eccles, and Kenny 2013). Even so, numerous studies within the STEM fields of education show that women tend to be less motivated, interested or less likely to participate in STEM education in comparison to men (Kanny, Sax, and Riggers-Piehl 2014). Studies also illustrate how STEM curricula tend to favour men (preferably those from high-educated backgrounds) (Sallee 2011; Paechter 2002). Women in Sweden also tend to complete their participation in higher education STEM programmes less often than men do, and work less often in STEM-related employment (Statistics Sweden 2013). In addition, while the focus of the study at hand is on specialization options within the upper secondary STEM domain, we are addressing the problematics outlined in Kanny, Sax, and Riggers-Piehl (2014). In their meta-study of STEM research, they showed how gender disparities within STEM are usually researched at an aggregated level, which leaves the complex relationships between subfields insufficiently investigated.
Departing from the Swedish example described above, our specific purpose with this study was to outline the ways in which gender relations are (re-)produced in line with policy reforms on multiple options and the re-organization of subject matters within upper secondary STEM programmes.

Policy reforms and structural differentiation

Central to this study is Ball’s (1994, 2003, 2010) discussion about the general changes in European education systems, and how they influence regulations, differentiation and outcomes in some contexts (see Erixon Arreman and Dovemark 2018). We also use Ball’s critique (cf. Beach’s 2018 critique) of how these changes have affected social differentiation within the education system. This critique emphasizes how social structures hold individuals and groups in a competitive and self-perpetuating hierarchy, even though they are constantly being re-defined (Ball 1994, 2010).

In line with this critique, we see how the introduction of a flexible course structure and selectable options in Swedish upper secondary school easily relates to ideas of flexible organizations and flexible workers in a rapidly changing labour market (SMER 1993a). When outlining the need for more options in 1997, policymakers were pressing the point that the high speed of change in all labour market sectors demands new knowledge and skills (SMER 1998). These new demands are articulated as possible to meet within the framework of the ‘new’ flexible upper secondary organization established in 1994 that would enable students ‘within certain frameworks [to] pursue their specific interests and abilities’ (SMER 1998, p. 58). Thus, by re-defining the structures of Swedish upper secondary education, the policy objectives of the late 1990s were to create more space for individual choices by enhancing the diversity of options. A structure built on multiple options was also viewed as a way to broaden participation, attracting new groups to different subject domains (SMER 1997). This idea of ‘broadening by specialization’, however, is somewhat contradictory to earlier reports on the need for a coherent system in order to reduce differences in accordance with social background factors (e.g. SMER 1993b). Thus, the necessity and the neutrality of options are legitimized by strong policy incentives related to ‘the market’ and ‘freedom of choice’ (Ball 1994, 2003).

Since the 1970s, issues of gender disparity within Swedish upper secondary education, have been investigated and debated in several reports (e.g. SMER 1980, 1981, 1997); however, later investigations have pointed out how gender disparity is a labour market issue rather than an educational one (e.g. SMER 2008). In the earlier reports, focus was placed on the gender and social equity differences that appear in vocational upper secondary programmes as well as in Natural Sciences and Technology programmes. For example, in 1994 the STEM domain in upper secondary education were re-organized into the Natural Sciences programme, although with the option to specialize within the programme, partly due to the heavy over-representation of boys pursuing studies within the field of technology (SMER 1993b). However, in 2000 this single national programme was divided into two programmes. The objectives underpinning this decision were outlined in the report 1997:107 (SMER 1997). In the report, enhanced freedom of choice was addressed in relation to the need to recruit more girls to the STEM domain and the committee behind the report emphasizes:
“... the importance of establishing educational opportunities within the Natural Sciences programme for students who wish to specialize in the areas of mathematics/computer sciences, bio-chemistry, or environmental care. The committee puts forward that girls might be interested in a Natural Sciences programme with one of these specializations.” (SMER 1997, p.98)

The report 1997:107 thus accentuates the introduction of specialized courses, particularly within the STEM domain, as an action to improve gender equality. However, the consequences of re-organizing upper secondary education in accordance with ideas of individual freedom of choice and the supposedly neutral opportunities immanent in specialization options are still to be investigated. Hence, just as Ball (2003, 2004) asked, we also ask what consequences the re-organized structure of education have been for the differentiating processes of education, here exemplified by the upper secondary education in Sweden.

Paechter (2002) also argues that education reforms affect structures and discourses in education but put particular focus on how education is formed by the hegemony of masculinity.

Both Paechter’s (2002) and Connell’s (2002) point is that power relationships, such as those part of the hegemony of masculinity, influence how western societies have created knowledge ideals as ‘free’ or ‘neutral’ and not contestable. Through discourses of ‘neutrality’ some subject areas, such as e.g. Mathematics, are seen as more valuable and important than other (c.f. Becher and Trowler 2001). Hence, within the education system, dominating discourses influence hegemonic relationships, which in turn form structures, ideas, and norms that are related to gender. These discourses are ‘performative’ in terms of how they both create and describe institutional practices (Paechter 2002). Closely related to Paechter (2002), Connell and Messerschmidt (2005) argue that discourses of masculinity historically have been defining the ruling legitimacy of certain norms, which is part of the way social hierarchies produce society. Further, they also argue that gender discourses need to be deconstructed continuously, in order to detect how the power relations behind gender structures and norms are redefined and sometimes resisted.

The above provides a basis for understanding how gender relations are reproduced through the school system, but may also open for insights on how options and ‘free choice’ relate to the hegemony of masculinity. In pursuing such an analysis, the STEM domain seems to be of particular interest. For example, the STEM domain in Swedish upper secondary education is at an aggregated level referred to as fairly gender equal (e.g. Swedish National Agency for Education 2017; Wedege 2011). Incongruently, this proposed gender balance does not reflect the skewed recruitment pattern to STEM programmes within higher education (Swedish Higher Education Authority 2016), nor how gender seems to affect completion rates or employment patterns (Statistics Sweden 2013). Further, the emphasis specifically applied to the STEM domain also illustrates its prominent status within the prestige economy and academic hierarchy (Mendick 2016), which may correspond to gender norms as a whole. Below we investigate further some of the possible mechanisms behind these patterns.

**Gender in the Swedish upper secondary STEM domain**

In this study, we used registry data originating from the Gothenburg Longitudinal Database (GOLD) to exemplify how patterns of gender and flexible options in upper
secondary education in Sweden are interrelated. When selecting four birth cohorts that included all youths born in 1978, 1982, 1988, and 1992 that were registered as Swedish citizens at the age of 16 (Table 1), we were given the opportunity to aggregate information on gender and detailed information on student enlistment in programmes as well as specialization options within programmes.

The four births cohorts represent the years between the vast reforms of 1994 (SMER 1994) and of 2011 (SMER 2011). During this period of time, municipalities were obliged to, as far as possible, adjust upper secondary intake in relation to previous application rates. Furthermore, all students who passed Swedish, Mathematics, and English in the comprehensive, nine-year compulsory school could transfer to an upper secondary national programme (Ball 1994). The choice of upper secondary programme for the cohorts at hand was thus dependent on pupils’ preferences; however, when the number of first choice applicants exceeded the capacity of a particular programme within a particular school, pupils’ grade point average from compulsory school was used as the differentiating measure.

Between 1994 and 2000, upper secondary education consisted of 16 national programmes, and up to 2011, there were 17 national programmes. During this period of time, both national programmes profiled as vocational and programmes profiled as academic preparatory provided a common set of courses which met the basic entry requirements for higher education. Also, each programme included a set of obligatory profile courses, meeting the specific entry requirements, for example within the STEM field of higher education. For the cohorts born in 1978 and 1982 interested in pursuing STEM studies, the Natural Sciences programme was offered as the overarching structure, although separated into two streams at the beginning of the second year. These two streams, the Natural Sciences stream, and the Technology stream, were in 2000 divided into two different programmes. Consequently, the cohorts born in 1988 and 2002 interested in pursuing STEM studies had a choice between the Natural Sciences programme and the Technology programme. For this study, to enable comparison over time, we therefore address the overarching structures as ‘mainstream’ upper secondary STEM education, with either a Natural Sciences or a Technology profile. Furthermore, to different extents, schools offered specialization options (year 2) within programmes. These specializations are of specific interest in this study, and thus we ask if students already enrolled in the STEM domain of upper secondary education make an additional

Table 1. Complete birth cohort and upper secondary STEM enrolment, frequencies and percentages (share within/share of birth cohort), divided by gender.

<table>
<thead>
<tr>
<th>Year of Birth</th>
<th>Second Year Enrolment</th>
<th>N</th>
<th>%</th>
<th>N</th>
<th>%</th>
<th>N</th>
<th>%</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete birth cohort</td>
<td></td>
<td>97,614</td>
<td>100</td>
<td>99,670</td>
<td>100</td>
<td>119,804</td>
<td>100</td>
<td>128,497</td>
<td>100</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>47,615</td>
<td>49</td>
<td>48,388</td>
<td>49</td>
<td>58,064</td>
<td>49</td>
<td>62,322</td>
<td>49</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>49,999</td>
<td>51</td>
<td>51,282</td>
<td>51</td>
<td>61,740</td>
<td>51</td>
<td>66,175</td>
<td>51</td>
</tr>
<tr>
<td>STEM domain</td>
<td></td>
<td>16,023</td>
<td>16</td>
<td>19,827</td>
<td>20</td>
<td>19,675</td>
<td>16</td>
<td>21,078</td>
<td>16</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>5,850</td>
<td>37</td>
<td>8,013</td>
<td>40</td>
<td>7,099</td>
<td>36</td>
<td>8,432</td>
<td>40</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>10,173</td>
<td>63</td>
<td>11,814</td>
<td>60</td>
<td>12,576</td>
<td>64</td>
<td>12,646</td>
<td>60</td>
</tr>
</tbody>
</table>

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choice or if they stay in ‘mainstream’, and how the different specialization options within
the STEM domain are distributed over gender.

From the birth cohorts of 1978, 1982, 1988, and 1992, we gathered information on
students’ course of study within the overarching STEM domain. The registration of
the second year was chosen in the analysis, because this was when choices away from
mainstream were registered. To connect the birth cohorts to the time period in focus, and
while students normally turn seventeen the year they start their fourth semester, we

As presented in Table 1, the distribution pattern for cohort 1999 is markedly different
from the other three cohorts while the general uptake in STEM in cohort 1999 is 20 percent
compared for 16 percent in the other cohorts. However, there is also a marked difference in
cohort sizes between the two oldest and newest cohorts (which is in line with the regular
fluctuations in Swedish population numbers) with a 20 percent increase of youths registered
as Swedish citizens between 1999 and 2005. In relation to the increased cohort sizes,
the decline seen in STEM uptake between cohort 1999 and the following ones is not present
in absolute numbers. One reason for this stability in absolute numbers may possibly be that
there were limitations in take up due to lack of resources such as teacher competence and
space when cohort sizes increased. Also, the large proportion of students enrolled within
the STEM domain in 1999 coincides with a general increase of students within the
academic preparatory upper secondary programmes during the 1990s. This increase
could possibly be related to the recession years of 1990–1994 and the high unemployment
rates during this period in time, reducing the labour market opportunities for youths
(Mellén 2017). Furthermore, the proportion of girls in relation to boys, within the STEM
domain fluctuates between 36 and 40 percent over time and there are no clear directions of
change. However, in 2009 there seems to be a small tendency towards a relative increase of
girls as 14 percent of the female population were enrolled within STEM at this point in
comparison with 12 percent in cohorts 1995 and 2005. Overall, however, the increased
STEM uptake in 1999 seems to be part of a general increase of students in academic
preparatory programmes, and the distribution patterns in relation to gender point at
stability rather than change during the time span in focus.

In the analysis of the seemingly stable gender relations of the upper secondary STEM
domain, distribution and change patterns were calculated and described for female and
male students separately. Distribution was thus calculated as the proportion of female/
male students within the STEM domain enrolled within a certain subject domain. The
change patterns are presented as percentage point differences in relation to cohort 1995,
which was the first cohort starting in the system of 1994 (SMER 1994). By referring each
subsequent birth cohort to cohort 1995 when illustrating changes over time, the intention
is to make visible the possible impact of the option structure implemented in 2000.
However, while we also aim to contribute to the understanding of how options and
choice interact, relations between all selected cohorts are of interest.

Expansion of options in the upper secondary STEM domain

In GOLD, information on different subject options is coded at an individual level for each
semester of upper secondary school and the expansion of options can thus be illustrated
by a number of codes registered per semester and cohort (Table 2). Table 2 illustrates
how while there were 36 codes for fourth-semester students enrolled within the upper secondary STEM domain for the 1995 cohort, only four years later, that number was 79. Moreover, the number of codes registered for the 2005 and 2009 cohorts were 224 and 298, respectively, which is an eightfold increase from the oldest to the newest cohort. Hence, although many codes represent similar subject areas, this expansion conforms to the general expansion of options related to the marketization of education.

In the analysis, we separated subject codes representing what we have referred to as the mainstream alternatives, which are the Natural Sciences and Technology streams (including codes representing small alterations in course of study), from codes representing specialization options. In the process of clustering, the codes were analysed on a nominal level and categorized into areas corresponding to how subject matters are classified and subsumed in upper secondary syllabi and how they relate to academic subject disciplines (a similar categorization is described in Swedish Higher Education Authority (2016)). The different categories derived from the subject codes are thus interconnected by the main subject addressed. However, the particularity of codes varied to different extents depending on the overarching subject area. For example, the specialization option categorized as Biology includes various codes concerning medicine and animal care, as well as environmental courses. The Mathematics category, in contrast, encompasses codes that predominantly address Mathematics, although also including the small fields of Physics and Astronomy. By the procedure of clustering codes, we also addressed the issue of anonymity. Although information on particular individuals is protected by the exchange of social security numbers with anonymous codes in GOLD, for some subject codes there are few or even just one individual registered per birth cohort. The risk of retracing these individuals is reduced by the aggregation of codes. Consequently, we have categorized the subject codes for each cohort into eight domains listed in Table 3 and discussed below.

### The illusive stability of the STEM domain

As described, the growing number of options following the reform of 1994 and the changes in 2000 can be interpreted as the ideas of ‘flexibility’ and ‘free choice’ being embodied in Swedish upper secondary education. In Table 3 the eight categories derived from the subject codes are listed alongside the distribution of cohorts and proportions in relation to total birth cohort. The two domains at the top of the list in Table 3 are clusters of codes representing ‘mainstream options’, which are the broad Natural Sciences or Technology. The six domains that follow are clusters of different ‘specialization options’. The number of students registered in an unknown code is below 1 percent, and these have been excluded from the subsequent analysis.

| Table 2. Number of subject codes within the upper secondary science domain, per cohort. |
|---|---|---|---|---|
| Subject codes | 36 | 79 | 224 | 298 |
Table 3 illustrates how students have responded to the increased number of options over time, and also makes it noticeable how some options have a wider spread than others. The options articulated as particularly important in Government Report 1997:107 (SMER 1997), are clearly emphasized in our material with Mathematics as the most expanding option enrolling only a few individuals in the two oldest cohorts to enrolling 8.6 percent of the cohort in 2005, followed by a decrease to 5.9 percent in cohort 2009. Although having fewer students enrolled, Computer Sciences and IT as well as Biology present a similar pattern of how the increase of options changes student distribution (Table 3).

The changes in structure and distribution can be the result of different policy incentives at various levels, e.g. concerning how a national area, municipal or school plan for different educational needs, future goals, but also in how specific schools are able to attract teacher competence, finances, and students. For example, while the 2005 cohort illustrates a massive increase of students specializing in all subfields, the seemingly decreasing interest for specializations from 2005 to 2009 is mostly due to the decrease in Mathematics, Computer Sciences, and Biology (Table 3). That is, on the one hand, opportunities for choice are enabled and restricted by the options offered, but on the other hand, the presence and development of options seem to be dependent on students’ responses.

**Gendered subject matters**

As illustrated above, the STEM domain of Swedish upper secondary education is restructured by an extensive increase in the range of specializations (see Table 3) following the arguments in Government Report 1997:107. The introduction of a more flexible structure through a wider spread of options was put in contrast to how traditional programmes were affecting student recruitment (SMER 1997). In addition, by introducing a wider spread of options in the STEM domain, the intention was to balance out gender disparities. However, one can also suspect that the increasing number of options not only changed the very structure of the Swedish upper secondary school but also its content and subject matters, learning activities, knowledge and performance (cf. Ball 1994; see also Öhrn and Holm 2014).
Paechter (2002) has pointed out how the gender gap in education and particularly in STEM education presupposes scientific knowledge as ‘neutral’, as did Francis (2000). However, this presupposed neutrality dismisses how the structures of subject matters are discursively formed through hegemonic relationships and how they cannot be set apart from their institutional practices (Connell 2002). When discourses of free choice and multiple options are expressed in policy and implemented in the Swedish upper secondary system, the norms and structures shaping and reshaping STEM subject matters are not taken into consideration. That is, the arguments for multiple options in Swedish education policy are articulated within the hegemonic, ‘pure knowledge’ claim of science education (Paechter 2002; Becher and Trowler 2001). Furthermore, it has been argued that the idea of ‘options’ and ‘free choice’ may mask how some knowledge, competence or/and groups of students are rated over others (Archer et al. 2017; Ringrose 2007). Accordingly, the assumption in Swedish education policy (SMER 1997, 1998), about how the introduction of multiple options will level gendered imbalances, can be questioned.

**Mainstream outflow and change**

Thus, after the reform in 1994, and particularly after the introduction of a wider spread of options in 2000, there is an extensive branching of the upper secondary STEM education. This branching results in a considerable mainstream outflow from the 1995 cohort, in which 96.8 percent of girls and 96.3 percent of boys attend a mainstream alternative, to the low point of the 2005 cohort, in which the proportions were 78.0 and 63.3 percent respectively. Thus, the change pattern between 1995 and 2005 is different between girls and boys, with a – 18.8 percentage point reduction for girls between the two cohorts in comparison to –33.1 points for boys (Tables 4 and 5). Thus, there is a marked difference regarding how boys and girls, respectively, respond to the emerging options.

**Table 4.** Distribution of female students in percent, unit percentage change from 1995, mainstream options specified.

<table>
<thead>
<tr>
<th>Cohort</th>
<th>1995</th>
<th>1999</th>
<th>Change</th>
<th>2005</th>
<th>Change</th>
<th>2009</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mainstream</td>
<td>5664</td>
<td>96.8</td>
<td>7449</td>
<td>93.0</td>
<td>–3.9</td>
<td>5534</td>
<td>78.0</td>
</tr>
<tr>
<td>NaSc</td>
<td>4905</td>
<td>83.8</td>
<td>6681</td>
<td>83.4</td>
<td>–0.5</td>
<td>5089</td>
<td>71.7</td>
</tr>
<tr>
<td>Technology</td>
<td>759</td>
<td>13.0</td>
<td>768</td>
<td>9.6</td>
<td>–3.4</td>
<td>445</td>
<td>6.3</td>
</tr>
<tr>
<td>Specialization</td>
<td>186</td>
<td>3.2</td>
<td>564</td>
<td>7.0</td>
<td>3.9</td>
<td>1562</td>
<td>22.0</td>
</tr>
<tr>
<td>Total</td>
<td>5850</td>
<td>100</td>
<td>8013</td>
<td>100</td>
<td></td>
<td>7096</td>
<td>100</td>
</tr>
</tbody>
</table>

**Table 5.** Distribution of male students in percent, unit percentage change from 1995, mainstream options specified.

<table>
<thead>
<tr>
<th>Cohort</th>
<th>1995</th>
<th>1999</th>
<th>Change</th>
<th>2005</th>
<th>Change</th>
<th>2009</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mainstream</td>
<td>9800</td>
<td>96.3</td>
<td>10,845</td>
<td>91.8</td>
<td>–4.5</td>
<td>7953</td>
<td>63.3</td>
</tr>
<tr>
<td>NaSc</td>
<td>5138</td>
<td>50.5</td>
<td>6669</td>
<td>56.4</td>
<td>5.9</td>
<td>5438</td>
<td>43.3</td>
</tr>
<tr>
<td>Technology</td>
<td>4662</td>
<td>45.8</td>
<td>4176</td>
<td>35.3</td>
<td>–10.5</td>
<td>2515</td>
<td>20.0</td>
</tr>
<tr>
<td>Specialization</td>
<td>373</td>
<td>3.7</td>
<td>969</td>
<td>8.2</td>
<td>4.5</td>
<td>4617</td>
<td>36.7</td>
</tr>
<tr>
<td>Total</td>
<td>10,173</td>
<td>100</td>
<td>11,814</td>
<td>100</td>
<td></td>
<td>12,570</td>
<td>100</td>
</tr>
</tbody>
</table>
Our earliest cohort (1995) illustrates how girls foremost attend in mainstream Science, far less in Technology. Also, for girls in 2005 and 2009, the Natural Sciences option is even more dominant in relation to Technology than in 1995, due to the mainstream outflow having a larger relative impact on the already small Technology stream (Table 4). The outflow from mainstream Technology is even more noticeable for boys, whereas there is a percentage unit reduction of −26.8 from 1995 to the low point of 2005. However, the distribution between mainstream Natural Sciences and Technology for male students differs considerably from the female pattern. In the 1995 cohort, 50.5 percent of the male students were enrolled within the Natural Sciences and 45.8 percent within Technology (Table 5), compared to 83.8/13.0 percent for female students (Table 4).

One conclusion to be drawn from the patterns expressed in Tables 4 and 5 is that the intention in Government Report 1997:107 (SMER 1997) to make the STEM domain and specifically Technology more attractive to girls was not reached. Instead, girls appear to have stayed in predominant or similar paths. A possible interpretation of this is that although there was a re-defined structure, in practice, the technology domain is not presented and/or viewed as an achievable or attractive domain for girls (Archer et al. 2017). This in turn may be related to how subject matters are structured and thus that they resonate differently between boys and girls (Francis et al. 2017; Paechter 2002; Walkerdine 1988).

So, there are noticeable differences regarding both representation and change patterns for male and female students in Tables 4 and 5 which illustrate, we argue, how gender is both the medium and the effect of how the STEM domain is structured over time. This claim is supported by several separate but intertwined observations. The initially low and then decreasing participation of girls within mainstream Technology suggests that a gender order is reproduced independently of both the reform aiming to make the domain more comprehensive by a stronger integration of the natural sciences and technology areas (SMER 1994), as well as by the reestablishment of the two partly separated programmes in 2000 (SMER 1998). In line with Paechter (2002), this indicates, that the gendered structure of upper secondary education not only is a consequence of how knowledge is organized into different programmes, but also how subject matters, as for example Technology, are reproduced as gender-specific by students’ responses and representation (see also Nyström 2012).

This illustrates that, while the gender imbalance within the mainstream options in general is reduced, this is not due to an increase in the number of girls. The results from our analysis suggest the opposite: that this reduction is due to a decrease in the number of boys. This ‘levelling by outflow’ can be argued to reinforce the mainstream options within the STEM domain and in particular the Natural Sciences, in contrast to the specialization options, as acceptable options for girls which also can be noticed in the admission patterns to STEM subjects in higher education (Sattari and Sandefur 2018; Swedish Higher Education Authority 2016). Also, the outflow of boys from the mainstream alternatives mainly stems from Technology, supporting the argument that the specialization process maintains or even enhances the gender-based asymmetry within the upper secondary STEM domain.

In summary, the emergence of options seemingly reproduces, redirects, and even reinforces existing gender divisions. By the gendered outflow patterns marked in Tables 4 and 5, we argue that the proposed gender equal balance, presented in Table 1, is
challenged. Moreover, these patterns might hide how institutional change affects divisions and flows. Below, we give two examples of how the increase of specialization appears to interact with gender just as with other values and interests over time.

**How to distinguish the distinguished**

As described, the specialization options within the Swedish upper secondary STEM domain are categorized into six subject areas. In Tables 6 and 7, the distribution pattern over the six categories of options is displayed for female and male students, respectively. The three first categories, Mathematics, Biology, and Computer Sciences and IT are the largest, while they represent the fields of specialization that were outlined as extra important in the early 2000s (SMER1997, 1998). Therefore, these areas will be the focus of the analysis below.

The most noticeable change demonstrated in Tables 6 and 7 is how Mathematics, which here also includes Physics, is a rather large subfield for both male and female students in 2005. However, the difference in the proportion of boys and girls enrolled within specialized Mathematics is also clearly marked. While 10.8 percent of boys attended Mathematics in 2005 (Table 7), only 4.8 percent of girls did alike (Table 6). This difference in Mathematics enrolment is reinforced up to 2009, while the increase of boys from baseline 1995 to 2009 is 8.1 percent and the increase of girls 2.1 percent. Thus, the dominance of

<table>
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<tr>
<th>Cohort</th>
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<th>N</th>
<th>%</th>
<th>1999</th>
<th>N</th>
<th>%</th>
<th>Change</th>
<th>2005</th>
<th>N</th>
<th>%</th>
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<th>2009</th>
<th>N</th>
<th>%</th>
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<td>7.0</td>
<td>-3.9</td>
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<th>%</th>
<th>1999</th>
<th>N</th>
<th>%</th>
<th>Change</th>
<th>2005</th>
<th>N</th>
<th>%</th>
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<th>2009</th>
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male students within the Mathematics specialization is even more considerable in 2009 than in 2005 (proportion of male/female 82/18 in 2009 cf. 80/20 in 2005)

For female students (Table 6), the specialization option with the highest representation of girls is Biology, culminating at 9.0 percent in 2005. Second to Biology is Mathematics, in which 4.8 percent of the girls within the STEM domain participated in 2005, but this representation reduced to 2.6 percent in 2009.

For male students (Table 7), Mathematics shows the highest representation over time, peaking at 10.8 in 2005. The second-largest area of specialization for male students was the emerging field of Computer Sciences and IT, with a peak of 10.1 in 2005. This area is also particularly male-dominated, while the representation of girls peaks at 1.3 percent (Table 6). For Mathematics as well as Computer Sciences and IT, the representation of male students consistently exceeds the representation of female students over time. For Biology, this relationship is the reverse. Noted in comparison is the pattern for Social Sciences, in which the representation of girls exceeded the representation of boys in 1995 and 1999, but shifted in the opposite direction in 2005 and 2009 (Tables 6 and 7).

Thus, there are clear examples in Tables 6 and 7 of how the options emerging in the ‘flexible’ organization of Swedish upper secondary school are part of differentiating processes. These processes seem to be working both across the division between broader and more specialized options as well as between (and presumably within) the diverse specialization categories.

As outlined and discernible in Tables 6 and 7, the area of Mathematics is particularly interesting in relation to gender disparity. As shown in previous research, this gender gap in enrolment could possibly at least partly be explained by comparative skill advantages (Aucejo and James 2016; Wang, Eccles, and Kenny 2013). However, the separation of Mathematics as a specialization option would also presumably reinforce the mathematical skills of those (predominantly boys) who enrol. Furthermore, from another perspective, Francis (2000) argues that subject areas often are placed in a hierarchy in which ‘science’ is associated with high-status traits such as rationality and objectivity, while ‘the fine arts’ are associated with emotion and subjectivity. This leads to subject-specific ‘assignments’ as more masculine or more feminine (Francis 2000, p 35) that can affect how school structures, programmes, and curricula are determined but also what are seen as acceptable femininities and masculinities in school practices. Also, similar understandings can be derived from previous research relating ideas of femininity and masculinity to discourses of academic achievement. In Skelton, Francis, and Read (2010), being an ‘acceptable girl’ is discussed as something not harmonizing with being a successful academic achiever. They conclude that the former often associates with passivity, accommodation, a concern with social relations and projecting feminine ‘desirability’ whilst the latter; as in ‘successful’, relates to demands, hard-nosed determination, singularity and concern with mental/intellectual (rather than with care or social) pursuits. Presumably, when highlighting Mathematics as an extra important area of knowledge (SMER1997), the link between Mathematics and academic achievement would be reinforced. Also, as displayed in Tables 6 and 7, the distinguishing of Mathematics can be interpreted as the reproduction of a gender-biased system. In accordance with this, our empirically based descriptions support the view that Mathematics and Physics are less accessible for girls, just as is also the case in Computer Sciences and IT.

Generally, we put forward that the distinction of Mathematics in the organization of upper secondary education is showcasing the ‘distinguished’, attracting those who are
pursuing intellectual growth rather than focusing on social relations. In our material, this growth is predominantly by boys. From these empirical findings we, as do Skelton, Francis, and Read (2010), argue that the organization of knowledge within the school system, as well as in society at large, circumscribes choice by its relation to acceptable femininities and masculinities. This argument is further supported below by the example of Computer Sciences and IT, and Biology.

The contingent structures of the specialization options

The pattern illustrated by the change between the cohorts presented, in line with contemporary research studies, show how the options available in this kind of school system are re-structured over time (e.g. Lundahl et al. 2010; Lundahl 2002). This is also illustrated by the emergence of Computer Sciences and IT as an area of specialization. In contrast to Mathematics and Biology, both based on traditional upper secondary practices, Computer Sciences and IT were introduced as a new field within upper secondary school in the 1980s (Söderlund 2000). Already in the two oldest cohorts, the field is dominated by boys with a representation of 1.4 in 1995 and 3.5 in 1999 (Table 7). Girls are also represented to some extent in the first two cohorts (0.2 and 0.9, Table 6), however, in the following decade, the male domination of the field was enhanced and the change pattern showed a noteworthy difference between boys and girls, with a percentage point increase of 1.1 percent for girls between 1995 and 2005 compared to an increase of 8.8 points for boys.

One possible conclusion to be drawn from this pattern is that while the field of Computer Sciences and IT at the beginning was an option to which a few interested students responded (mainly boys; fewer girls), this interest became structured and defined as a male sub-area over time. This development can possibly be explained by how Computer Sciences and IT are connoted with the field of ‘technical’ science, and that technical fields such as mainstream Technology (Tables 4 and 5) and in particular, Specialized Technology (Tables 6 and 7) are extensively and consistently male-dominated, which in turn can correspond with the hegemony of masculinity (Archer et al. 2018; Connell 2002).

Departing in the withstanding understanding of Mathematics as a ‘pure’ and intellectual pursuit (Paechter 2002; Becher and Trowler 2001), the difference in proportions of female and male attendance in this specialization can be understood in accordance with how academic success is produced through education, relative to notions of acceptable masculinities and femininities (Sallee 2011; Skelton, Francis, and Read 2010; Paechter 2002). While Mathematics, just as Computer Sciences and IT, is interconnected by the understanding of a consistent and ‘pure’ knowledge object (see Becher and Trowler 2001), the sub-domain here categorized as Biology (as outlined above) consists of various specializations directed towards environmental, human or animal conditions. Even though it is similar to Mathematics, Biology as a field of specialization showed a large growth over time while expanding among the older cohorts. However, the disproportion between male and female students here is the reverse from the case with Mathematics. While 9.0 percent of the girls in the 2005 cohort were enrolled within the area of Biology, only 4.0 percent of boys were similarly enrolled (Tables 6 and 7). Also, the pattern of change for Biology
shows a larger percentage point increase for girls than for boys over time (in 2005 a 5.6 and 3.3 unit percentage change for girls and boys, respectively, Tables 6 and 7).

One possible way to interpret this difference, the high proportion of girls enrolled within Biology compared to boys in Mathematics, is by its relationship to ‘care’ or ‘service’ (for the environment, humans, animals). Using Francis (2000), we argue that Biology, in comparison to Mathematics or Computer Sciences, may be more related to aspects of emotion and social relations, and therefore an option assigned femininity (c.f. Sallee 2011). A similar view is described in Archer’s et al. (2018) study, where the general profile of the science student as white, middle-class and male is problematized. They find that the normalization of talking science through muscular intellect (competition, domination, and control) point to the continued separation of ‘mind’ and ‘body’ (the Cartesian split), and the privileging of ‘mind’ as an authentic signifier of male scientific intellect. Other ways of talking science, expressed mainly by girls and more quiet boys, was less recognized and valued (Archer et al. 2018). Therefore, we may also argue that the specialization of the STEM domain (we illustrate above) creates a demarcation of a more emotional, social or caring view or interest (in, e.g. Biology) from the ‘distinguished minds’ of Mathematics. Options can thus be argued to not only reproduce a system that differentiates in accordance with this kind of gender order, but the specialization processes also seemingly enhance these reproducing forces over time.

The analysis above demonstrates on the one hand that offering Mathematics as a specialized subject area, although appearing to be gender neutral in Swedish upper secondary policy (SMER 1997), apparently resonates with the boys in the material to a greater extent than with the girls, seemingly reinforcing Mathematics as a male domain. While Mathematics is structured around notions of intelligence and mind, the over-representation of boys consequently also reinforces the notion of mind as masculine (Paechter 2002). On the other hand, offering caretaking subjects within a framework of Biology structures gender by offering an acceptable path for the ‘other’ (cf. Paechter 2002; Walkerdine 1988) resonating with girls to a greater extent than with boys, possibly structuring and dividing both options and choices for the subsequent cohorts.

Concluding remarks

This study departs in the overarching question about how the flexible option system in Swedish upper secondary school, initiated by the reform in 1994, differentiates on the basis of gender. By using large-scale registry data, we have shown the consequences of school market reforms on subject matters, ‘free choice’ and gender. We have also tried to problematize the, on an aggregated level, seemingly stable gender relations in the Swedish upper secondary STEM domain over time.

Our results show how the emergence of multiple options within the STEM domain reproduces differences, and even enhances differentiating processes, on at least two different but interrelated levels: Firstly, by changing the system in accordance with a general market logic emphasizing ‘freedom of choice’, and, secondly, by distinguishing predominantly gender-specific subject matters. Most apparent, maybe, our results illustrate how the mainstream outflow in the STEM domain is dominated by boys, and how this seems to enhance the gender-based asymmetry within this domain over time. We also argue that our results challenge the proposed neutrality of what is often referred to as
free choice’ (e.g. SMER 1997). Instead, our study shows how the distribution of female and male students in this domain relates, respectively, to how the proportion of students within mainstream STEM alternatives changes over time, and how this mainstream ‘outflow’ of students is shaped by, but also shapes, the growing number of specialization options just as by a rather stable gender order. Through these results we are able to claim that boys and girls respond differently when the school system is made flexible alongside the general marketization of education and the growing need of flexible workers (cf. Lidström, Holm, and Lundstrom 2014; Lund 2008). That is, while boys more than girls seemed to respond to options such as Mathematics, Computer Sciences and IT, they most probably also respond to a gender curriculum (Paechter 2002) just as to subjects’ that are highly specialized. Therefore, boys’ responses are not only different from girls’, but also more in demand just as more rewarded (Statistics Sweden 2013). In general, girls choose the broad option of mainstream Natural Sciences and to some extent the more diverse area of Biology. Also, when policy addresses girls in terms of ‘deficiency’, boys’ attendance within the STEM domain is imposed as a norm, thus maintaining the hegemonic relationship between science and masculinity.

While the STEM domain provides high-stakes education, it opens up opportunities for both boys and girls to progress to higher education and in the long run, for access to well paid jobs. However, when these opportunities differ between boys and girls, this risks affecting how men and women act in the higher education STEM domain (Swedish Higher Education Authority 2016) just as in the labour market (Statistics Sweden 2013). The differentiating options outlined above tell us that these differences are already reproduced and reinforced by a diversified upper secondary educational system.

Finally, we therefore argue that when policy enhances the importance of gender equality, flexibility and freedom of choice in Swedish upper secondary STEM education by implementing a supposedly neutral option structure, this is done through the predominant gender order that is neither free nor flexible.

Disclosure statement

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Johanna Mellén is currently pursuing a PhD in Education at the Department of Education and Special Education, University of Gothenburg, Sweden. Her thesis work is part of a larger project, drawing on longitudinal registry data, investigating changes in the Swedish school system from the 1990s up to today. In her research, Johanna takes particular interest in the relationship between educational reforms, student recruitment, and gender.

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Petra Angervall [http://orcid.org/0000-0003-2425-2088](http://orcid.org/0000-0003-2425-2088)

**References**


