Context and Implications Document for: Recruitment to STEM studies: The roles of curriculum reforms, flexibility of choice, and attitudes

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Introduction

In many countries, the recruitment to education in Science, Technology, Engineering and Mathematics (STEM) is viewed as insufficient relative to the needs arising through increasingly rapid technological change and growing challenges with respect to, for example, the environment, energy supply and pandemics. The deficiency is especially marked with respect to female students. To increase STEM studies, some countries have implemented upper secondary curriculum reforms. In the Netherlands, the number of study options has been reduced and STEM alternatives emphasised. In Germany, students have been required to take advanced mathematics, where they formerly could choose between basic and advanced mathematics. In England, the Royal Society has formulated a vision implying that all students should study mathematics and science up to age 18.

We assess a Swedish upper secondary curriculum reform in 1995 that was similar to the proposal launched by the Royal Society. Moreover, there was a later reform, implemented in 2011, that reversed many of the changes of the earlier one, allowing us to compare two reforms going in opposite directions, in one and the same country. We also consider attitudes to STEM and flexibility with respect to the choice of study path as these may also impact on STEM recruitment, directly and indirectly, by influencing the reactions to curriculum reforms.
Implications for Policy

Five implications for policy are provided. Each of the implications are first concisely stated and then explained and motivated.

**Policy implication 1**: Longitudinal data constitute an essential source of information for evaluations of educational reforms.

The intentions of educational reforms can be very different from the resulting outcomes. To capture the actual changes in behaviour among those affected by the reform, data spanning both pre- and post-reform periods, as well as the reform itself, are required, that is, longitudinal data.

Our empirical analyses are based on register data—longitudinal data which are also population data—covering all students admitted to upper secondary education in Sweden between 1986 and 2017. They show, for example, that the 1995 curriculum reform, which aimed at making vocational programmes more attractive by extending them from two to three years, including more STEM and other academic studies, and providing eligibility for university studies, decreased the shares of students enrolled on STEM vocational programmes. Moreover, among the students that chose STEM-oriented vocational programmes the completion rate declined and the share proceeding to university studies was unaffected.

**Policy implication 2**: Curriculum reforms intended to increase STEM studies are likely to be more successful if they employ positive incentives than if they are based on requirements.

In 2002, the German federal state Baden-Württemberg implemented a reform requiring students to take advanced mathematics where they formerly could choose between basic and advanced mathematics. The reform had no effect on the results in mathematics among male students. While mathematics results improved among female students, their upper secondary drop-out rate increased too. The Swedish reform in 1995, requiring students on vocational programmes to stay on an additional year, to enable more academic studies, including STEM, was not very successful either (Policy implication 1).

A ‘soft’ alternative was tried in the Netherlands. In 1998, a large number of upper secondary study options was limited to only four study profiles, among which two were STEM-oriented. The reform reduced the female under-representation in STEM studies. However, with respect to the two STEM profiles, the male students predominantly chose the more STEM-intensive ‘Science and Technology’ profile while the majority of the female STEM students opted for the ‘Science and Health’ profile.

It seems, however, that by means of positive incentives, the gender bias in STEM can be overcome. In Sweden, a Supplementary 1-year Upper Secondary Science/Technology Education programme was introduced in 1992, targeting students that had completed a 3-year upper secondary academic, but non-STEM, programme. The supplementary education yields skills corresponding to those provided by the academic upper secondary Science or Technology and Engineering programmes. A strong incentive for completing the supplementary education programme is that
students doing so are guaranteed a study place at an appropriate university Science or Engineering programme the following year. The supplementary education programme has substantially increased STEM studies, especially among females. In 2014, more than 3000 female students were admitted to the supplementary education programme whereas the number admitted to the upper secondary Science or Technology and Engineering programmes was 7400. For males, the corresponding numbers were 2000 and 8400, respectively.

Policy implication 3: Flexibility in the choice of study path and unconventional combinations of study domains and subjects can boost STEM recruitment.

STEM studies are demanding. One would thus expect that for students uncertain about whether they will cope with the studies, it should be important that the risks associated with choosing an upper secondary STEM programme be kept low. Swedish experiences support this conjecture.

First, changing programme is easy, common, and not stigmatising. Accordingly, more students ‘at the margin’ try a STEM programme, than would have been the case, had the (first) choice of programme been (more) decisive.

Second, the 4-year Technology and Engineering programme owes much of its popularity to the feature that it incorporates an alternative to the long-term commitment to higher education studies that otherwise is associated with the choice of an academic upper secondary STEM programme. Specifically, after three years of academic studies the students can choose between going to university or undertaking one year of vocational training, yielding a well-respected professional qualification.

Third, by combining academic non-STEM and STEM studies, the Supplementary 1-year Upper Secondary Science/Technology Education programme (see Policy implication 2) constitutes a low-risk, high-reward STEM option for students that already have shown themselves to be fit for academic studies. The risk is low because the students only commit to one extra year of study and do so when they have a fallback option—a completed academic upper secondary programme making them eligible to non-STEM university studies. The reward is high because of the guaranteed study place at university, if the supplementary education is completed in one year.

Policy implication 4: It is possible to substantially increase the recruitment to STEM studies among female students.

Female students make up the largest potential recruitment pool for STEM studies. It is crucial, therefore, to increase female students’ interest and engagement in the STEM field. Swedish experiences show that it can be done, by means of concerted, long-term efforts by the government, educational authorities and the labour market organisations. Examples of measures taken are information campaigns, extended study counselling, and use of older female students as role models. In the wake of these endeavours, female enrolment on academic upper secondary STEM programmes has increased and female students have entered vocational STEM programmes traditionally dominated by male students. The Supplementary 1-year Upper Secondary Science/Technology Education programme has also been particularly beneficial for female students (see Policy implication 2). Most importantly, the
share of female students proceeding to STEM university studies has risen by almost 2.5 times between the mid-1980s and 2012, from 5% to over 12%.

**Policy implication 5:** A high proportion of male students participating in STEM studies cannot be taken for granted.

A high male participation in STEM studies often seems to be taken as given. Data for Sweden indicate that this can be a dangerous presumption. Whereas the male enrolment rate on academic upper secondary STEM programmes was close to 30% in the mid-1980s, it was below 20% in 2012. An important factor behind the downturn was the partial dismantling of the Technology and Engineering programme (dominated by male students) that took place between 1990 and 2010 and meant that the option to attend one year of vocational training after the third academic year was taken away. After the reinstatement of this option in 2011, enrolment increased again but still did not exceed 20% in 2017, the end of our period of observation.

Fortunately, this negative development was compensated for by an enlarged inflow to vocational upper secondary STEM programmes and students attending the Supplementary 1-year Upper Secondary Science/Technology Education. Due to these channels, the share of male students proceeding to STEM university studies increased from 12% to 13% between the mid-1980s and 2012, which, however, is very modest compared to the female rate (see Policy Implication 4).

**Authors Recommend**

For a discussion about the use of register data, that is, longitudinal population data, in educational research, see Mellander (2017). The German curriculum reform has been assessed by Görlitz and Gravert (2016, 2018) and Hübner et al. (2017) and the consequences of the reform in the Netherlands have been considered by van Langen et al. (2008). The current system of upper secondary education in England is described by Hupkau et al. (2017) while the Royal Society’s vision concerning its reformation is formulated in Royal Society (2014, 2018). A pilot scheme preceding the first curriculum reform in Sweden has been evaluated by Hall (2012).

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Focus Questions

1. Why is there a need for increased recruitment to STEM studies?
2. Why do students not respond (more strongly) to this need?
3. In what respects do the views on STEM studies differ between female and male students?
4. What measures would be most effective to increase the interest in STEM among female and male students, respectively, given the current curriculum and structure of upper secondary education?
5. If the upper secondary education could be redesigned, what kind of changes in the curriculum and/or the organisation would be most likely to increase the participation in STEM studies?

Seminar Idea: New ways to increase the recruitment to STEM studies

Educational reforms seeking to increase the study of STEM subjects in upper secondary education by requiring students to take STEM courses have not been very successful (see Policy implication 2).

This raises the question if new ways can be found to increase the recruitment to STEM studies, based on free choice of study programme and the creation of novel study paths. In particular, can options traditionally regarded as substitutes provide a solution if they, instead, are viewed as complements and, thus, possible to combine? The idea can be illustrated by two Swedish examples.

The first example concerns a combination of non-STEM and STEM studies. By means of 1-year ‘add-on’ science/technology education, students with a completed academic non-STEM upper secondary programme can become eligible to STEM university studies. While this prolongs their studies from three to four years it provides them with a very broad upper secondary education and a guaranteed study place at an appropriate university science/technology programme, if they complete the supplementary education within the stipulated year (see Policy implication 3).

The second example involves a combination of academic and vocational studies. In the Technology and Engineering programme, the first three years are devoted to academic studies, yielding eligibility to university technology and engineering education.
However, the third year can also be followed by one year of vocational studies, yielding a professional qualification. Accordingly, the students need not decide on a long university education when they enrol on this programme; they have an exit option which is well recognised in the labour market (see Policy implication 3).

Issues to consider: Could these examples be applied to other countries? Are there institutional obstacles, like limits on the maximum number of years spent in upper secondary, or regulations preventing changes of study path? If so, could they be eliminated?