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The Long-Run Effects of STEM-Hours in High School: Evidence From Dutch Administrative Data

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The Long-Run Effects of STEM-Hours in High School: Evidence from Dutch Administrative Data*

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Abstract

We analyze the short- and long-run effects of a policy change in Dutch secondary schools, which aimed at increasing the fraction of STEM graduates overall and in particular among previously underrepresented groups. Mandatory STEM hours were reduced in the STEM field, which is a prerequisite for enrolling in a STEM major at university. Hours decreased more strongly in the academic track (required for enrollment in research universities) than in the technical track (required for universities of applied sciences). Employing a difference-in-difference approach with Dutch administrative data, we find that the policy led to a significant increase in the take-up of the STEM field in high school, especially for women. In the longer-run, however, enrollment in STEM majors at university did not increase. Instead, after the policy change previously underrepresented groups, such as women and individuals from low-income families, were even relatively less likely to pursue a STEM degree. The decrease of women graduating from STEM was primarily driven by women with STEM parents, suggesting that it was due to negative signals about their preparedness for a STEM major.

JEL Classification: I23, I28, J24
Keywords: STEM; curriculum change; major choice; educational, labor and family formation outcomes

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1 Introduction

Technological progress in recent decades strongly suggests that future economic growth can primarily be expected in the fields of science, technology, engineering and mathematics (STEM) (OECD, 2010). Between 2020 and 2030, the demand for STEM graduates is expected to grow by 9.1 percent in Europe (Cedefop, 2020) and by 10.8 percent in the U.S. (BLS, 2021) (compared to 4.4 and 4.9 percent for all other occupations, respectively). It is a worldwide challenge to keep up with this growing demand. According to the U.S. Department of Education (2017), only 18 percent of Bachelor degrees were awarded in STEM fields in 2016. This is partly due to an underrepresentation of women. Despite the fact that women received 58 percent of all Bachelor degrees, they only received 36 percent of all STEM Bachelor degrees. Besides women, also minorities and students from less privileged families are underrepresented in STEM fields worldwide (Griffith (2010); Kokkelenberg and Sinha (2010)). Students from these groups are less likely to choose a STEM major in university and the ones that do are more likely to drop out (Chen and Soldner, 2014). One particular focus among policy makers is therefore to enact policies aimed at tapping the unused potential, especially among the underrepresented groups, to increase the supply of STEM graduates.

Why is the fraction of students graduating in STEM fields so low, despite the fact that STEM graduates have higher earnings than graduates from other fields (e.g. Abramitzky et al. (2019), Altonji et al. (2016), Ardiciacono (2004), James et al. (1989)) and despite the fact that vacancies in this sector are many and foreseen to increase further? Which factors contribute to the underrepresentation of women, minorities and students from less privileged families in the STEM field? Students face a utility maximization problem when deciding about their college major, taking both expected monetary and non-monetary benefits and costs into account. For example, students may opt for non-STEM majors, because of higher effort costs of obtaining a STEM major (due to its quantitative nature), which may outweigh the longer-run benefits of better prospects in the labor market. Related to this point, drop-out rates in STEM fields are higher and grade averages in STEM fields tend to be lower (Ahn et al., 2019). While studies suggest that women have lower effort costs of studying, women may opt out of STEM because they care more about achieving good grades (Ahn et al., 2019) and may be more risk averse with respect to higher drop-out rates. Another reason, in particular for the underrepresentation of women, minorities and students from less privileged background, may be lack of information about the STEM field, i.e. about whether students would find it interesting/enjoy it and whether they have the necessary skills. Therefore, policies that aim to draw students into the STEM field, giving them the opportunity to experience and gain interest in the STEM field, may be effective, in particular for students with less exposure to STEM and fewer STEM-related role models.

One such policy has been enacted in the Netherlands in 2007. The Dutch government changed the secondary school curriculum, reducing the number of mandatory STEM hours in the STEM field, to attract more students, in particular from underrepresented groups, to this area.[1] The STEM field in secondary school (*Nature/Tech*) plays a critical role in that graduating with this specialization is the prerequisite for choosing a STEM major at university. This holds for students assigned to the academic track in high school (required to enrol in a research university), as well as for students assigned to the technical track (necessary for enrolling in a university of applied sciences). To increase the accessibility and attractiveness of *Nature/Tech* in secondary school, the Dutch government lowered the work load in terms of field-specific course hours starting in 2007, and the reduction was particularly strong in the academic track. This first cohort affected by the reform was already in the third year of secondary school (and thus already assiged to a track), but had not yet entered the specialization phase in which they have to choose a particular field to graduate in, while the control cohort had just entered the specialization phase and already made their field choice. We make use of the differential reduction in STEM hours in the two tracks by employing a difference-in-differences design combined with Dutch administrative data to analyze the short- and medium-run effects of the curriculum change on enrolling in and graduating from high school with a STEM specialization. Moreover, we investigate the longer-run effects in terms of enrollment and graduation with a STEM bachelor or master and, more generally, in terms of long-run labor market and family formation outcomes. Lastly, we present results for the pooled sample and for different groups and make use of the detailed administrative data to shed some light on the underlying mechanisms.

More specifically, the policy change implied a reduction in the number of mandatory hours in field-specific courses (such as math and physics in *Nature/Tech*) by 17.5 percent in the academic track (compared to 6.9 percent in the applied university track), while the number of hours of freely elective subjects increased to fully compensate for the drop in hours in field-specific courses. Since study load and effort costs tend to be highest for quantitative subjects, such as mathematics and physics, we expect the decrease in field-specific hours to have the largest effects on study load and effort costs in the STEM field *Nature/Tech*. With the exception of the differential drop in field-specific hours, the two high school tracks (academic and applied university track) resemble each other in important ways, such as in terms of students having to choose a field to graduate in and only being able to enroll in a STEM major at university if graduating with the

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[1] According to OECD (2023), in 2021 19% of B.A., M.A. and Ph.D. students graduated with a STEM degree in the Netherlands, compared to slightly higher fractions in the Unites States and the OECD overall (22% and 23%, respectively). While women form a clear majority in higher education overall (56% in the Netherlands compared to the OECD average of 58%), they are still under-represented in the traditionally male-dominated science, technology, engineering and mathematics (STEM) fields (33% in terms of OECD average, 32% in the Netherlands), ranging from 20% or less in Chile and Japan to 40% or more in Greece, Iceland, New Zealand and Poland. Interestingly, the share is above 40% in many partner countries (Argentina, India, Romania, Saudi Arabia and South Africa).

field *Nature/Tech*. Moreover, the fraction of students choosing *Nature/Tech* developed in the same way in both tracks in the years prior to the reform, consistent with the parallel trend assumption underlying the difference-in-differences (DID) approach. Therefore, we apply the DID methodology to analyze the effect of the reduction in mandatory STEM hours in the STEM field in the short-run, that is we investigate if the likelihood of graduating from high school with *Nature/Tech* increases. Moreover, we examine the causal effect of the policy change in the longer-run, in terms of the probability of graduating with a STEM bachelor degree and STEM master degree. In addition, we analyze the policy's impact on other long-run outcomes, such as labor market earnings and marriage and fertility outcomes when students are in their late twenties/early thirties. Lastly, we analyze whether and how effects differ for different groups, such as female/male students and students from different family backgrounds.

To analyse the causal effect of lowering the effort costs for graduating high school with the *Nature/Tech* field, we use Dutch administrative microdata from Statistics Netherlands (CBS). This dataset contains information on the entire Dutch population in terms of their family background, educational histories (including the track in secondary school, field choice, academic grades/GPA in secondary school, college major choice as well as highest obtained degree in college), labor market outcomes and marriage and fertility outcomes. The first cohort after the policy change is currently observed until age 29. Thus we can follow students for nearly 15 years after their field choice and for more than ten years after graduating from secondary school, allowing us to observe their full educational histories including bachelor and master degrees, and labor and family formation outcomes until students' late twenties/early thirties.

Our main findings are as follows: First, investigating the short-run effect of the reduction in mandatory STEM hours on the likelihood of graduating from high school with *Nature/Tech*, we find that the policy increased the likelihood of specializing in *Nature/Tech* by 11 percentage points (from a baseline of 17 percent in the academic track) and thus substantially increased the fraction of students satisfying the formal requirements to enrol in a STEM major at university.

Second, we analyze the short-run effects on subgroups of the population and find stronger direct effects of the policy change on female than male students. Women's likelihood of graduating high school with *Nature/Tech* increased by 14 percentage points compared to only 7 percentage points for men. The policy thereby reduced the gender gap by nearly 7 percentage points (from 23 to 16 percentage points) and consequently the prospective gender gap in terms of STEM enrollment at university. In terms of socioeconomic background on the other hand, the policy increased the gap between low- and high-income students. While students from less privileged households increased the likelihood of graduating with *Nature/Tech* by 7 percentage points, students from more privileged backgrounds increased the likelihood significantly more (by 11 percentage points), thereby increasing the socioeconomic status gap. Thus, in the short-run, the policy (partially) met the intended goals: Overall a substantially larger fraction of students met the formal requirement to enrol in a STEM field at university and the gender gap decreased. On the other hand, the socioeconomic status gap increased somewhat.[2]

Third, the effects we find in the medium and longer-run paint a different picture. Despite the fact that the fraction of students satisfying the formal requirements for STEM at university went up substantially, the likelihood of enrolling into or graduating with a STEM bachelor or master remains unchanged.

Fourth, while the policy led to a slight increase in terms of male students graduating with a STEM degree (by 1.4 percentage points in terms of STEM bachelor and by 1 percentage point in terms of STEM master), the effect on women is significantly smaller and, more specifically, there is no increase (or even a slight decrease) for women graduating with a STEM degree. Thus in the longer-run the policy led to a widening of the existing gender gap in STEM graduates, contrary to what was intended. Also the socioeconomic status gap increased in response to the policy. Already in the short-run low-income students increased their take-up of *Nature/Tech* in high school to a significantly smaller extent than high-income students. In the longer-run in terms of graduating with a STEM major the gap not only increased, but low-income students were significantly less likely (even in absolute terms) to obtain a STEM master degree in response to the policy.

Fifth, we investigate the underlying mechanisms behind the observed short-run and long-run effects of the policy. In the short-run, the reduction in mandatory STEM hours (in particular in math and physics) in the STEM field *Nature/Tech* implied an important decrease in the effort costs of graduating from high school in *Nature/Tech*. The policy most likely also raised the expected GPA of graduating in *Nature/Tech*, since grades now depended to a smaller extent on the performance in STEM subjects, which tend to be graded more strictly. At the same time obtaining a high school degree with STEM field still holds the option value of being able to choose any college major including STEM, and has the advantage of improved skills in quantitative subjects and a more prestigious high school degree and different social network with benefits in the labor and marriage market (even without university attendance or STEM at university).

Since the curriculum change had the direct implication of lowering the costs of graduating with *Nature/Tech*, we would expect students to increase the take-up of *Nature/Tech* in high school. It is less clear what to expect in the longer-run and what to expect for groups previously underrepresented in STEM, such as women and low-income students. The idea underlying the policy was to draw students into STEM and give them the opportunity to experience and gain interest in the STEM field, in particular students who had less exposure to STEM and fewer role models prior to the reform. In the short-run this turned out to work, at least for women who increased their

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[2] We also conducted a heterogeneity analysis by migration background, using different classifications, but we do not find any significant differences in short- or long-run effects by migration background.

take-up of STEM in high school more strongly than men. In the longer-run however, while there was a slight increase in male high school graduates and high school graduates from higher-income families who took up the opportunity to pursue a STEM degree in college, there was no change or even a decrease in terms of female students and lower-income students graduating from college with a STEM major. Why did women and low-income students not increase or even decrease their likelihood to graduate with a STEM degree?

One important direct implication of the policy is that high school students graduating in *Nature/Tech* have acquired less field-specific knowledge, in particular in terms of math and physics, than prior to the reform. It is well-known that women and men differ in terms of self-confidence and that men tend to be more self-confident or even overoptimistic with respect to their abilities (see, e.g., Morin (2015), Preckel et al. (2008), Niederle and Versterlund (2007)). Thus, one possible explanation for women decreasing their likelihood of pursuing STEM in college relative to men may be that STEM high school graduates are now less well prepared for pursuing a STEM degree in college. Worse preparation implies a higher likelihood of drop-out and worse expected grades, which women seem to be particularly concerned about, while being less confident in their own abilities. Similarly, it has been shown that students from less privileged backgrounds tend to be less self-confident (Guyon and Huillery, 2021). Moreover, they are less able to compensate the reduction in STEM hours, for example via remedial tutoring or help of the parents, since low-income students have fewer resources and are substantially less likely to have parents with a college degree, let alone with a STEM degree.

To investigate the role of having parents who have the resources or skills to compensate for the lack in preparedness, we analyze heterogeneous effects in terms of policy impact on male and female students by whether at least one of their parents has a college degree or a STEM degree. On the one hand, students with more highly educated parents may be better able to compensate and learn the necessary skills outside of high school or university. On the other hand, more educated parents and in particular parents with STEM degrees, are also more aware that their children lack important abilities and knowledge for pursuing STEM, which increases the (expected) costs of a STEM major in college.

Our results show that the decision of women not to pursue a STEM degree in college in response to the reform was linked to the educational background of their parents. The curriculum change had particularly negative effects on women with STEM parent(s), that is women with at least one STEM parent were 3.8 percentage points less likely to obtain a STEM bachelor and 2.4 percentage points less likely to obtain a STEM master in response to the policy change compared to women without STEM parents. The same does not hold for women with college-educated parents. This is consistent with a story that women receive the signal from their STEM parents that they lack fundamental skills for pursuing a STEM degree in college. This makes the pursuit of a

STEM degree not only more costly in terms of study effort than prior to the reform, but it importantly also leads to the expectation of worse grades and a higher risk of drop-out. While for male students with STEM parents, the returns to STEM appear to still outweigh the increase in study costs (possibly also due to higher self-confidence/overconfidence and thus higher expected grades and/or a lesser concern with worse grades, see Ahn et al. (2019)), the same is not true for female students.

These results indicate that lowering the prerequisites in high school to enroll in a STEM major will ultimately not lead to more female STEM graduates. Female students need stronger signals of mathematical ability to choose male-dominated STEM subjects, even when they have the same grades (Justman and Méndez, 2018). Therefore, while lowering STEM prerequisites in high school appears to induce women to increase the take-up of the STEM field in high school, ultimately such a policy backfires and reduces the number of female STEM graduates at university, because women feel less prepared in the relevant STEM subjects.

Why did women increase the take-up of *Nature/Tech* in high school in the first place, and more strongly than men? First, we show that women (and high-income students) responded more strongly to the policy, the higher the fraction of high-income students in *Nature/Tech* already prior to the reform, i.e. the effect on women and high-income students appears to have been reinforced via peer effects.[3] This might be one factor for why we see a stronger increase in the take-up of *Nature/Tech* in high school among women and high-income students. How did the change in social network and in the pool of potential partners affect women's long-run outcomes? What are the effects of the policy on long-run labor market and family formation outcomes for women with STEM parents, who reduced their likelihood of graduating from college with STEM bachelor or master in response to the policy?

We find that the policy led to an increase in labor earnings of women with STEM parents, potentially driven by better quantitative skills (due to *Nature/Tech* in high school, albeit a reduced likelihood of STEM bachelor or master) or by a stonger social network in high school. Moreover, the likelihood of having a spouse also increased (and the likelihood of children increased relative to women without STEM parents, but not in absolute terms). While it is certainly insightful to investigate even longer-run effects on labor market and marriage outcomes of students into their mid-/late-thirties, by their late twenties most students have already been in the labor force for several years (even if they have a bachelor or master degree) and a large fraction of people is married. Thus our results suggest that the long-term effect of choosing *Nature/Tech* in high school, but opting out of a STEM bachelor or master, appears to have had positive or at least no negative long-run effects on women with STEM parents, consistent with them (correctly) anticipating the

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[3] Interestingly, we do not find that female students increased the take-up of *Nature/Tech* more strongly, the larger the fraction of female students prior to the reform.

lack of preparedness after the curriculum change.

Our paper is related to the following four strands of the literature: First and closest to our paper is a recent small, but growing, literature investigating the effects of curriculum changes in STEM subjects in high school on the STEM major choice. Biewen and Schwerter (2022) make use of a policy change in Germany making math compulsory in the last two years of high school, which increases the share of STEM students and increases the gender gap. De Philippis (2021) analyzes the effect of a policy change in the UK that led to more schools offering advanced science in high school and finds an increase in the share of STEM students and a widening of the gender gap.

Compared to these papers we analyze what are the short- and long-run effects on STEM and other outcomes of **reducing** the number of mandatory STEM hours. Investigating the impact of this policy change is interesting for at least three main reasons. First, effects might not be monotonous, thus the impact of a reduction in mandatory STEM hours might not be equivalent to the negative of the effect of an increase. Second, the two existing papers look at making math hours mandatory or at the effect of more schools offering/introducing advanced science classes, so the marginal individuals affected by these policies are likely to be quite different. Third, in the light of the fact that both analyzed policies led to increases in the gender gap, it is interesting and highly policy relevant to understand the effect of a policy which had the goal to increase STEM exposure and draw students into STEM, in particular among previously underrepresented groups such as women and students from less privileged households. Moreover, we provide evidence not only in terms of short- and long-run STEM outcomes, but also on labor market and family formation outcomes, and we show results for further subgroups, such as for students from different socio-economic and migration backgrounds. Lastly, we are able to shed some light on the underlying mechanisms, by investigating - among other aspects- effects depending on whether or not students' parents have a STEM or college degree and how effects vary depending on the peer group.

Second, another related strand of literature investigates the effect of changes in math curriculum. Joensen and Nielsen (2009) and Joensen and Nielsen (2016) analyze the effect of a curriculum change in Denmark, which allows students to combine advanced math with biology for graduating with a STEM field. They find that the policy increased education and earnings and led women to take more intensive math subjects and more competitive careers decreasing gender gaps. We complement their findings by evaluating a different type of policy, providing more direct evidence on long-run STEM outcomes and by analyzing the heterogeneity of effects by socioeconomic status and migration background. Two other papers evaluating the effects of changes in math instruction time on disadvantaged groups (low-skilled 9th graders and African Americans) find positive effects on educational outcomes and earnings (see Cortes et al. (2015) and Goodman (2019)).[4] Lavy

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[4] Two papers that are not evaluating policy changes are Delaney and Devereux (2019) and Aucejo and James (2021) who investigate the relevance of math and verbal skills for university enrollment and performance and in the former

(2015) and Abramitzky et al. (2019) analyze the effects of instruction time of different school subjects on educational achievement.

Third, the literature on college major choice is also related to our paper (see, among others, Zafar (2013), Altonji et al. (2016)) and more specifically on the choice of a STEM major (see, e.g., Ahn et al. (2019)). Our paper contributes to this literature by showing the relevance of curriculum changes on STEM major choice overall and for different subgroups.

Lastly, our paper is linked to a literature analyzing different types of policies aimed at decreasing the gender gap in STEM, for example by providing students with female role models (see, e.g., Bettinger and Long (2005), Carrell et al. (2010) and Breda et al. (2020)). We show that the policy of making access to the STEM field easier by decreasing mandatory STEM hours raises take-up and decreases the gender gap in the short-run, but backfires in the longer-run by actually increasing the gender gap in terms of graduating with a STEM bachelor or master.

This paper is organized as follows. Section 2 discusses the institutional framework in the Netherlands and describes the policy change. The following section 3 describes the empirical model, the data used in the analysis and provides descriptive statistics. Section 4 analyzes the results. Concluding remarks are offered in section 6.

2 Institutional Framework

In this section, we briefly discuss how STEM graduation rates in the Netherlands compare to other countries (overall and by gender). We then describe the system of secondary education in the Netherlands and the enrollment in tertiary education. Lastly, we describe the policy change and how it affected students in the different tracks of secondary school.

2.1 Facts on STEM Graduation Rates Overall and by Gender

According to OECD (2023), in 2021 19% of B.A., M.A. and Ph.D. students graduated with a STEM degree in the Netherlands, compared to slightly higher fractions in the US and the OECD overall (22% and 23%, respectively). While women form a clear majority in higher education overall (56% in the Netherlands compared to the OECD average of 58%), they are still underrepresented in the traditionally male-dominated science, technology, engineering and mathematics (STEM) fields (33% in terms of OECD average, 32% in the Netherlands), ranging from 20% or less in Chile and Japan to 40% or more in Greece, Iceland, New Zealand and Poland. Interestingly, the share is above 40% in many partner countries (Argentina, India, Romania, Saudi Arabia and South Africa).

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case also on the likelihood of acquiring a STEM degree.

2.2 Secondary Education in the Netherlands

At age 12, students complete primary school and transition to (mandatory) secondary school. They enroll in one of three tracks in secondary school: the academic track leading up to studying at a research university (*VWO*), the technical track leading up to universities of applied sciences (*HAVO*) and the vocational track (*VMBO*). The allocation of students to these tracks is based on the primary school teachers' recommendation and centralized test-scores. In what follows, we will only look at the first two tracks, the academic and the technical track, because only these two tracks allow students to study at university and only they were affected by the policy. These two tracks combined contain around 45 percent of all Dutch secondary school students.

In the first three years of secondary school, all courses are mandatory in each of the two tracks. At the start of the fourth year, students choose a field of specialization. They can choose between four possible fields: "Natuur en Techniek" (Nature and Technology), "Natuur en Gezondheid" (Nature and Health), "Economie en Maatschappij" (Economics and Society) and "Cultuur en Maatschappij" (Culture and Society). The field choice is critical for the major choice in tertiary education. For example, only the field Nature and Technology (*Nature/Tech*) gives access to all possible university majors during bachelor studies and is the only field that gives access to STEM bachelors. The other fields only give access to a subset of bachelors.

For each field, students have to take a combination of three or four subjects that are mandatory for the specific field. For *Nature/Tech*, these subjects are Physics, Chemistry and Mathematics B, which has the most intensive and challenging math curriculum. Beside the field part, students have to take compulsory subjects like Dutch, English and physical education that have to be followed regardless of the field choice. Moreover, there is an elective part where students are required to take one or two extra electives, which may be related to the field choice or not.[5] At the end of secondary school, all students write a centralized exam.

2.3 Tertiary Education in the Netherlands

The academic as well as the technical track satisfy the requirements of the Dutch compulsory education law. This means that graduates from the two tracks can either leave the education system or pursue a Bachelor's degree. Graduates from the technical track (*HAVO* degree) can go to a university of applied sciences (*HBO*) and graduates from the academic track (*VWO* degree) can go

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[5] Due to the electives, it is possible for a student to meet the criteria to graduate in two or more fields. Officially, you can graduate with up to two fields of specialization. Most commonly, these combinations are the similar fields "Nature and Technology" and "Nature and Health" on the one hand, and "Economics and Society" and "Culture and Society" on the other hand. In this paper, we consider someone who has graduated high school with the subjects Physics, Chemistry and Mathematics B as *Nature/Tech* graduates, since these students will have access to all (STEM) bachelors.

to either a research university (*WO*) or a university of applied sciences.

In contrast to the U.S. system, students have to pick a major as soon as they enroll at university. When enrolling for a major at a research university or at a university of applied sciences, the first admission criterion is the field of specialization in secondary school. To enroll in a STEM major, the student needs to have a secondary school degree with the *Nature/Tech* field. In fact, (only) graduating secondary school with a *Nature/Tech* specialization gives access to all bachelors including STEM. In terms of which subjects are counted towards the STEM field, we rely on the definition of the commonly used International standard classication of education (ISCED, 2011) according to which categories 4 and 5 are considered to be STEM majors. The majors belonging to these groups are displayed in Table A.1 the Online Appendix.

With a *Nature/Tech* degree, a bare pass suffices for enrollment in any bachelor without quota.[6] Due to the large demand for STEM graduates, there are barely any quotas for STEM majors. The only STEM major which had a limit on admissions for the treated (academic track) group was Clinical Technology at the University of Twente (DUO, 2011). However, the enrollment that year did not exceed the quota. So anybody with a *Nature/Tech* degree who wanted to pursue a STEM major, could enroll in the major at the university of their first choice.

To conclude, since enrollment in a STEM major is only possible with the *Nature/Tech* field, any student not choosing *Nature/Tech* at the end of their third year of secondary education (at age 15) will lose the opportunity to obtain a STEM degree at university. This makes the field choice in high school a high-stakes decision with longrun consequences.

2.4 Policy Change

In August 2007, changes were applied to the curriculum of the second stage of secondary school, during which students specialize in a certain field.[7] The Dutch Ministries of Education, Economic Affairs and Social Affairs and Employment collaborated in the form of a platform *Platform Beta Techniek*, which was founded in 2004. Its main goal was to increase the fraction of students choosing and completing the *Nature/Tech* field, especially among women, since in the cohorts before the policy change, less 10 percent of female students graduated secondary school with the *Nature/Tech* field. Two other goals were to simplify the structure of the second stage and to give

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[6] Secondary school grades are only important for bachelor studies with a quota. This applies, for example, to medicine at research universities or physiotherapy at universities of applied sciences. For some majors, there are quota at certain universities, but not at others (e.g. business administration). When selecting students, universities generally place a higher value on a *Nature/Tech* degree than on a degree in one of the other fields. However, a selection committee for a major such as Business Administration might value a prospective student with an Economics and Society degree with perfect grades more than one with a bare pass for *Nature/Tech*.

[7] The policy change is documented in Adviespunt (2007) written by the institution *Tweede Fase Adviespunt*, which advised the Dutch Ministry of Education until 2009.

students more freedom in choosing their curriculum by allotting extra time to electives (du Pre, 2005).

The curriculum change was as follows: In the academic track (*VWO*), the number of course hours for the field part decreased by 17 percent (from 1,840 to 1,520 hours). This implies that *Nature/Tech* students in the academic track spend two hours and 40 minutes less per week on the three STEM subjects (math, physics and chemistry). In the technical track (*HAVO*), the field part decreased by seven percent (from 1,160 to 1,080 hours), equivalent to *Nature/Tech* students in the technical track spending only one hour per week less on the three STEM subjects after the policy change. In both tracks, the number of hours for electives increased accordingly, so that total instruction time remained the same, allowing students more freedom in choosing their curriculum. The second (field) stage was subject to a few other changes beside the reduction in STEM hours. For example, the number of hours for mandatory courses without final exam (such as P.E.) decreased. However, all other changes in the second stage were either identical for both tracks or independent of the field choice. Therefore, any differential change in field choices in the academic and technical track should be due to the differential changes in course hours in the field part.[8]

The reform thus decreased the number of field-specific hours, which –in the STEM field– are all quantitative in nature, requiring a larger study effort, while generally being graded more strictly. Thereby the curriculum change lowered the bar to obtain the most-highly valued degree in secondary schools, *Nature/Tech*. At the same time, a reduction in the number of STEM hours in *Nature/Tech* decreased the level of STEM-specific knowledge that students obtain in preparation for studying STEM at university without the option to have the same level of STEM preparation as before the policy change (see, e.g., Lavy (2020) and Lavy (2015) who show that hours of instruction are a good proxy for the knowledge acquired in a course).

The policy change went into effect on August 1, 2007, and applied to everyone who was about to enter the fourth year of the academic (*VWO*) and technical (*HAVO*) track, starting with the academic year 2007-2008. This policy did not affect older cohorts in the higher years in 2007. More specifically, the cohort born between 1 October 1990 and 30 September 1991 was aged 16 and attending grade 11 at the time of the reform in 2007. The reform did not apply to this cohort, as they had already chosen their field and the number of field-specific hours remained at the level prior to the reform until they completed secondary education. Instead, the cohort born one year later (between 1 October 1991 and 30 September 1992), were aged 15 and attending grade 10. Thus, they were the first cohort to whom the reform applied. They started and completed the field given the new rules. When they had to choose their field (i.e. *Nature/Tech* or one of the other three), the new cohort was aware of the change in field-specific hours as the law passed

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[8] A summary of the policy changes is displayed in Table A.2 in the Online Appendix.

in April 2006 (Wijzigingswet Voortgezet Onderwijs, 2006), more than a year before they had to make their field choice. Using individuals' birth year is the conservative way to classify students to avoid selection concerns, due to students skipping or repeating an academic year in response to the policy.

3 Empirical Strategy and Data

3.1 Empirical Strategy

In the empirical analysis, we exploit the policy change of 2007, which reduced field-specific hours in the academic (*VWO*) relative to the technical (*HAVO*) track. As discussed in the previous section, students experienced a reduction of 17.5 percent in the academic track (compared to 6.9 percent in the applied university track). Since the field courses in the STEM field (math, physics, chemistry) are all quantitative in nature and particularly difficult, requiring a larger study effort than other courses, while generally being graded more strictly, the policy change led to particularly strong decrease in the study load and effort costs of the STEM field. This means that the reform made it easier to meet the prerequisites for a STEM major (i.e. the completion of the *Nature/Tech* field in secondary school) in the academic (*VWO*) relative to the technical (*HAVO*) track. With the exception of the differential drop in field-specific hours, the two high school tracks (academic and applied university track) resemble each other in important ways, such as in terms of students having to choose a field to graduate in and only being able to enroll in a STEM major at university if graduating with the field *Nature/Tech*.

We make use of the differential reduction in STEM hours in the two tracks by employing a difference-in-differences design combined with Dutch administrative data to analyze the short-, medium- and long-run effects of the curriculum change. In particular, we compare a younger cohort of students (born after October 1, 1991) who are affected by the policy change and an older cohort (not affected by the reform), as discussed in the previous section. Students in the academic track (*VWO*) constitute the treatment group (large reduction of field specific hours) and students in the technical track (*HAVO*) the control group (small reduction of field-specific hours), which we employ to control for counterfactual trends, i.e. for how decisions would have changed in the absence of the reform.[9][10] As will show below that the fraction of students choosing *Nature/Tech*

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[9] As discussed in the previous section, at the time of the policy change the younger cohort affected by the reform was already in the third year of secondary school (and thus already assiged to a track), but had not yet entered the specialization phase in which they have to choose a particular field to graduate in. The control cohort instead had already entered the specialization phase and made their field choice.

[10] To identify the total effect of the change in field-specific hours on choices, it would have been ideal if there had been no corresponding change in the technical track. However, evaluating the effect of a large reduction of field-specific hours (*VWO*) compared to a smaller reduction (*HAVO*) should lead to conservative estimates of the effects and

developed in the same way in both tracks in the years prior to the reform, lending support to the parallel trend assumption underlying the difference-in-differences (DID) approach.

Our main specification can be seen in Equation (1), where Y_{itc} denotes the outcome of interest, including the short-term choice of the field *Nature/Tech* as well as a number of medium- and longer-run outcomes. VWO_{it} is an indicator which takes the value 1 for if student *i* is in the academic track (*VWO*) and 0 otherwise (i.e. if in the technical track, *HAVO*) . LC_{ic} is an indicator which is 1 if student *i* is born in the later-born cohort affected by the policy change and 0 if student *i* is born in the earlier-born cohort unaffected by the policy change. $Treatment_{itc}$ is an indicator which takes the value 1 if a student is in the later-born treated cohort and in the VWO (i.e. the treated) track. X_{itc} includes a set of controls including gender, migration background, parental background and municipality of residence. β_1 denotes the coefficient of interest and shows the causal effect of the policy reform.

$$y_{itc} = \beta_0 + \beta_1 * Treatment_{itc} + \beta_2 * VWO_{it} + \beta_3 * LC_{ic} + X_{itc} * \gamma + \epsilon_{itc} \tag{1}$$

As increasing the representation of underrepresented groups in STEM fields was one of the main goals of the policy change, it is important to investigate whether and how the effects of the reform differed for different subgroups. We therefore also estimate a fully interacted model with a group indicator G (see Equation (2)), where the main coefficient of interest δ_1 can be interpreted as a differential treatment effect.

$$\begin{aligned} y_{ist} = \beta_0 + \beta_1 * Treatment_{itc} + \beta_2 * LC_{ic} + \beta_3 * VWO_{it} + \delta_1 * Treatment_{itc} * G_{itc} \\ + \delta_2 * LC_{ic} * G_{itc} + \delta_3 * VWO_{it} * G_{itc} + X_{itc} * \gamma + \epsilon_{itc} \end{aligned} \tag{2}$$

When the interaction effects show a significantly different response to the reform for a particular subgroup, we also estimate the non-interacted DID model (see Equation (1)) on the relevant subgroups. We look consider gender, migration background and socio-economic status (household income) as our subgroups of interest for our heterogeneity analysis.

3.2 Data

Our study is based on own estimations and calculations using the non-public administrative micro-database from Statistics Netherlands (Centraal Bureau voor de Statistiek, CBS).[11] This database contains information on the entire Dutch population and are particularly suitable for our purpose, since they contain information on month and year of birth and educational histories including

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provide us with lower bounds of the true effect, as discussed further below.

[11] Under certain conditions, these non-public microdata are accessible for statistical and scientific research. For further information: microdata@cbs.nl

track in secondary school (such as academic and technical track), fields in secondary school (such as *Nature/Tech*), highest completed degree (such as bachelor, master) and college majory (such as STEM). Moreover, we have information on yearly income, individual and household characteristics, such as gender, socio-economic status of the family, parental education and occupation (including STEM background) and migration background.

Importantly, for all students in the relevant cohorts we have information on their track allocation, their field choice, their tertiary education enrollments and degrees until 2021 and their income until 2020. In the following sections, we describe the definition and construction of the variables we use and present descriptive statistics.

3.2.1 Construction of Variables

In this section, we describe the variables we use from the CBS micro-database for our analysis as well as how we constructed these variables. The main dependent variables we are looking at are related to short-run and long-run educational attainment. In terms of short-run outcomes, we are interested in whether the STEM field *Nature/Tech* is chosen or not. *Nature/Tech* is a dummy variable that takes the value of 1 if a student completed secondary school with the *Nature/Tech* field and 0 otherwise.

Our main medium- to long-term outcomes are whether the student enrolls in and completes a STEM bachelor or STEM master degree at university. *STEM Bachelor* and *STEM Master* take the value of 1 if a student obtained a Bachelor and Master in one of the STEM fields, respectively, and 0 otherwise. *Graduation delay* is the number of months that a student needed to graduate on top of the expected time to completion.

In terms of longrun outcomes, we consider the individual's own income, whether the individual is married/has a partner, whether the individual has children. Moreover, we look at characteristics of the partner, such as partner's income, whether the partner has a *Nature/Tech* degree and whether the partner has obtained a STEM bachelor or master. *Personal income* is the logarithmic personal income of an individual at age 28. *Partner* takes the value of 1 if an individual has a registered partner or a spouse by age 29, and 0 otherwise. *Married* takes the value of 1 if an individual has a spouse by age 29, and 0 otherwise. *Child(ren)* takes the value of 1 if an individual has at least one child by age 29, and 0 otherwise. *Partner Personal income* is the logarithmic personal income of the partner of the individual when the individual is aged 28. *Partner Nature/Tech*, *Partner STEM Bachelor* and *Partner STEM Master* take the value of 1 when the partner of the individual has a *Nature/Tech* degree, a STEM bachelor or a STEM master, respectively, and 0 otherwise.

We analyze the heterogeneity of effects of the policy along three dimensions, gender, socio-economic status and migration background. The corresponding variables are defined as follows. *Female* take the value 1 if a student is female and 0 otherwise. *Migration Background* is 1 if the student or at least one of their parents are born outside of the Netherlands.[12] Finally, we categorize the cohorts by household income in the year when students are choosing their high school field. *Low Income* takes the value 1 if a student is from a low-income household. Since students in the two highest tracks in secondary school are from the more privileged part of society, only around 20 percent of students have a household income below the 60th percentile. To have a sufficient number of households in the *Low Income* category, while the variable still captures coming from a less privileged background, we use the 60th percentile based on which we define a Low or High Income background. Alternative definitions generate similar results (as discussed further below).

3.2.2 Descriptive Statistics

We present descriptive statistics of the main variables used in our analysis in Table 1.

[Table 1 here]

As expected, there are some differences between students in the academic (*VWO*) and in the technical track (*HAVO*). Students in the academic track of high school are somewhat more likely to, among others, be female (54 versus 51%), come from a two parents household (77 versus 72%), come from a higher income household (percentile 78 versus 72) and have at least one parent with a higher education degree (34 versus 24%). However, the differences within tracks and between cohorts are small and mostly insignificant.

4 Short- und Long-Run Effects of the Reduction in STEM Hours

In this Section, we employ a DID approach and Dutch administrative data to analyze the effect of the reduction in mandatory STEM hours in the STEM field in the short-run, that is we investigate if the likelihood of graduating from high school with *Nature/Tech* increases. Moreover, we examine the causal effect of the policy change in the longer-run, in terms of the probability of graduating with a STEM bachelor degree and STEM master degree. In addition, we analyze the policy's impact on other long-run outcomes, such as labor market earnings and marriage and fertility outcomes when students are in their late twenties/early thirties. Lastly, we analyze whether and how short-, medium- and long-term effects differ for different groups, such as female/male students and students from different family backgrounds.

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[12] We also considered alternative definitions, such as students with a non-Western migration background or students with at least both parents born abroad, which led to similar results.

4.1 Short-Run Effects: Graduating in *Nature/Tech* in Secondary School

We start by analyzing the effect of the curriculum change on graduating secondary education with the *Nature/Tech* field. We first show the results graphically and then present regression results in tables. In our regression analysis we investigate the pooled effects as well as effects separately by gender and household income to investigate if the policy change positively affected students from groups that were previously underrepresented in STEM .[13]

[Figure 1 here]

Figure 1 illustrates the shortrun effects of the curriculum change, i.e. the reduction in STEM hours in the STEM field, which was substantially larger in the academic as opposed to the technical track. As expected, the likelihood of choosing *Nature/Tech* increased in the academic track (*VWO*) and substantially more strongly than in the technical track (*HAVO*). More specifically, the fraction of *Nature/Tech* graduates in *VWO* increased by 14.7 percentage points (from 17.3 percent in the earlier cohort –still subject to the old rules– to 32 percent among the younger cohort subject to the reduction in field-specific hours). Meanwhile in *HAVO*, there is an increase in the take-up of *Nature/Tech*, albeit to a much smaller extent (increase of 4.1 percentage points from 11.1 to 15.2 percent). As we use individuals' birth year as the conservative way to classify students into early and late cohort to avoid selection, there is a slight increase in the take-up of *Nature/Tech* already one birth cohort earlier, because some students in the earlier birth cohort repeat an academic year and decide upon their field/specialization under the new set of rules.

To analyze the causal effect of the curriculum change on the likelihood of completing a *Nature/Tech* degree, we estimate Equation (1) on the pooled sample. More specifically, we analyze how the likelihood of completing the *Nature/Tech* field changed for the treated (younger) cohort compared to the control (older) cohort in the *VWO* (academic) track, in which students experienced the drastic reduction in field-specific hours, using as the counterfactual trend the change in the likelihood of *Nature/Tech* in the *HAVO* (technical) track, where students only experienced a minor decrease in field-specific hours. We present results from specifications without and with controls. To provide supporting evidence for the parallel trend assumption, we also present results from a placebo test investigating whether pre-reform trends (for two earlier cohorts) were indeed parallel for the two tracks.

[Table 2 here]

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[13] We also analyze effects by migration background, but we do not find differential responses to the policy change (see Table A.3 in the Online Appendix).

Table 2 displays the short-run effects of the policy in terms of the completion of the *Nature/Tech* field. In Panel A, the effect is shown for all students, while Panel B shows the effect by gender and Panel C by household income. Columns (1) and (2) present the main results (without and with controls, respectively), while Columns (3) and (4) display results of the placebo test providing evidence on whether pre-trends are parallel (again without and with controls, respectively).

According to Table 2, Panel A, the reduction in STEM hours leads to an increase in the likelihood of graduating secondary school with a *Nature/Tech* degree by 10.8 percentage points. The effect is significantly different from zero at the one-percent level.

In Panel B, to analyze whether the effect of the policy differed by gender, we estimate the regression from Equation (1) separately by gender and use a triple interaction from Equation (2) to determine if the causal effect of the policy change is statistically different based on gender of the student. While, the likelihood of graduating with the *Nature/Tech* field increased for both genders in response to the reduction in STEM hours, women are more strongly affected than man. Their likelihood of graduating with a *Nature/Tech* degree increases by 13.7 percentage points as opposed to 7.4 percentage points for men (the difference is significant at the 1-percent level).

Panel C of Table 2 shows that students from high and low income households are positively affected by the reduction in STEM hours. However, the effect of the curriculum change is substantially and significantly stronger for students from more priviledged backgrounds, in that their likelihood of graduating with the *Nature/Tech* field increases by 11.5 as opposed to 7.4 percentage points (the difference is again significant at the 1-percent level).

The placebo test results show that pre-trends in terms of graduating with *Nature/Tech* are virtually identical in the academic (*VWO*) and technical (*HAVO*) track, for the pooled sample and by subgroup. All coefficients are smaller than the absolute value of 0.04 and mostly below 0.01 and none of the coefficients is significantly different from zero. This lends support for the parallel trend assumption underlying our DID analysis.

To conclude, in the short-run, the reduction in STEM hours led to a significant increase in the likelihood of obtaining a *Nature/Tech* degree, overall and for each of the subgroups. While the gender gap in graduating with *Nature/Tech* actually decreased, as intended by the policy change, the gap between high and low SES students obtaining a *Nature/Tech* degree increased. Since graduating high school with a *Nature/Tech* degree is the prerequisite for enrolling in a STEM major at college/university, this may have important implications for graduating from college/university in the STEM field and for the gender gap in obtaining a STEM degree, which we investigate in the following section.

4.2 Longer-Run Effects: STEM Major at University

The ultimate goal of the curriculum change was the increase in the overall fraction of university graduates with a STEM bachelor or master degree and, in particular, an increase for previously underrepresented groups in the STEM field, such as women. Table 3 therefore displays the longer-run effects of the reduction in STEM hours on graduating university with a STEM bachelor or master degree. In Panel A, the effect is shown for all students, while Panel B shows the effect by gender and Panel C by household income. Columns (1) and (2) present results for graduating with a STEM Bachelor (main results and placebo test, respectively), while Columns (3) and (4) display results for the STEM Master degree (main results and placebo test, respectively).

[Table 3 here]

Table 3, Panel A, shows that the reduction in STEM hours in high school did not lead to any overall increase in the likelihood of graduating with a STEM bachelor or master degree, despite important short-run increases of 10.8 percentage points in obtaining the prerequisite for enrolling in STEM at university. In fact, the coefficients are 0.005 and 0.002 for STEM bachelor and master, respectively, and neither is significantly different from zero. Thus, the main goal of the policy of increasing the fraction of students graduating from university with a STEM degree was certainly not achieved.

As displayed in Panel B of Table 3, while the likelihood of men to graduate with a STEM degree increased slightly, it did not for women. In particular, the reduction in STEM hours in high school led to an increased likelihood of men obtaining a STEM bachelor by 1.4 percentage points and a STEM master by one percentage points (significant at the 1 and 5 percent level, respectively). For women, on the other hand, the estimated coefficients are even negative, albeit not significant, with coefficients of -0.05 and -0.03. The differences in results by gender appear surprising at first sight, as the positive short-run effects of the policy in terms of graduating with *Nature/Tech* were actually substantially larger for women than men. We investigate the underlying mechanisms in the next section. Our results imply, however, that contrary to the stated goal of the policy, the gender gap in terms of fraction of students graduating with a STEM degree actually increased in response to the policy.

In terms of heterogeneity by parental background, Panel C of Table 3 shows that the likelihood of graduating with a STEM bachelor degree increases by 0.7 percentage for students from high-income households (significant at the 5-percent level). The coefficient for graduating with a STEM master is 0.5 percentage points, albeit not significant. For students from lower-income households, on the other hand, the likelihood of graduating with a STEM bachelor remains unchanged, while the likelihood of obtaining a STEM master even decreases by 1.2 percentage points (significant at the 10-percent level). While this is consistent with the short-run effect of a stronger increase in the likelihood of graduating with *Nature/Tech* for more privileged students, it implies that the policy led to an increase in the socio-economic status gap of graduating from university with a STEM degree.

The placebo test results show that pre-trends in terms of graduating with a STEM bachelor or master degree are virtually identical in the academic and technical track, for the pooled sample and for all subgroups. All coefficients are smaller than the absolute value of 0.04 and mostly below 0.01 and none of the coefficients is significantly different from zero. This lends support for the parallel trend assumption underlying our DID analysis.

To conclude, the reduction of STEM hours in high school did not lead to an overall increase in the likelihood of graduating with a STEM bachelor or master, contrary to the goals of the curriculum change. Moreover, in the longer-run the policy actually increased the gender gap and the socio-economic status gap in terms of graduating with a STEM degree, contrary to its main goals. In the following section, we investigate the underlying mechanisms. In particular we aim to shed some light on why women's likelihood of obtaining a *Nature/Tech* high school degree increased (and more than the one of men), but the likelihood of graduating with a STEM bachelor/master remained unchanged (or even decreased relative to the one of men).

5 Mechanisms

In this section we examine the underlying mechanisms behind the results discussed so far. Most importantly, we address the question why there is no increase in the likelihood of women graduating from college with a STEM degree, despite an increase of 13.7 percentage points of obtaining the prerequisites for a STEM major. Put differently, why does the likelihood of graduating from high school with *Nature/Tech* increase more for women than men in response to the policy, but the likelihood of graduating with a STEM degree from college increases less (in fact, not at all).

One potentially very important factor that changed in response to the policy is the level of preparation and STEM-specific knowledge of students graduating with *Nature/Tech*, since the number of STEM hours taught in high school decreased. This is likely to affect students with or without college-educated parents and, a fortiori, with parents with or without STEM college degree differentially. On the one hand, college-educated and STEM-educated parents have the resources and may be better in helping their children in terms of preparation and remedial programs. On the other hand, more educated parents and, in particular, parents with a STEM degree will also be more aware of the lack of preparation of their children. Apart from this, lack of preparation may have very different effects on men and women, as discussed further below.

5.1 Parental Education

In this section, we examine heterogeneity in treatment effect by gender and whether any parent is college educated/ has a STEM degree or not. As discussed above, it is ex-ante not clear whether we would expect more positive treatment effects for students with more educated parents (since they have resources or remedial progams) or whether we would expect less positive/more negative treatment effects, since parents are more aware of the lack of preparation. The latter should be stronger for parents with STEM degree, since they are more aware of the preparation and knowledge needed for studying STEM at university.

[Table 4 here]

In Table 4, we display the effect of the curriculum change for people without and with STEM parents (in Panel A overall, in Panel B1 for women and in Panel B2 for men). In terms of outcomes, we show short-term results for the likelihood of graduating from secondary school with a *Nature/Tech* degree (Column (1)) and longer-term results in terms of graduating from university with a STEM bachelor or master (Columns (2) and (3), respectively). We therefore estimate an interacted model with interactions with the variable *STEM parents*, which takes the value 1 if at least one parent has a degree in higher education in a STEM field and 0 otherwise.

Table 4, Column (1), shows that the policy change led to an increase in graduating with *Nature/Tech* for students with non-STEM parents of 10 percentage points, while the increase was substantially stronger for students with STEM parents (17 percentage points, where the difference is significant at the 1-percent level). This is true both for women and men. For women the treatment effect is 7.5 percentage points larger when having STEM-educated parents (while the treatment effect for non-STEM parents is 12.8 percentage points) and for men the treatment effect is 6 percentage points larger with STEM-educated parents (while the treatment effect for non-STEM parents is 6.6 percentage points). The differences between treatment effects for STEM and non-STEM parents is significant at the 1-percent level for both women and men.

Examining heterogeneous effects on long-term outcomes instead (see Table 4, Columns (2) and (3)), we find no differential effects on students with or without STEM parents overall (in fact the coefficient on the interaction between treatment and *STEM parents* is negative, albeit small and not significant). Investigating the differential effect for STEM versus no-STEM parents separately by gender, we see some interesting patterns. In particular, for women the treatment effect of the policy was in fact significantly negative, but only for women with STEM-educated parents. For women without STEM parents the policy had no effect on the likelihood of obtaining a STEM bachelor or master, but for women with STEM parents the policy actually decreased the likelihood of obtaining a STEM bachelor by 3.8 percentage points (significant at the 1-percent level) and the likelihood of obtaining a STEM master by 2.4 percentage points (significnat at the 10-percent level). For men on the other hand, the policy increased the likelihood of STEM bachelor by 1.2 percentage points and by 1.1 percentage points and there is no differential effect for men with STEM educated parents (the coefficient on the interaction is however positive, but small with values of 0.018 and 0.002 and insignificant, as opposed to what we see for women).

[Table 5 here]

We now conduct a similar heterogeneity analysis, but by whether parents are college-educated (independent of their major) or not. While students with college-educated parents would have the resources for remedial/tutoring programs to make up for lack of STEM knowledge (independently of whether parents have an actual STEM degree), STEM parents would be more likely to understand the lack of preparedness given the reduction in STEM hours in secondary school.[14] We are therefore interested to see, whether we find the same pattern as for the interaction with STEM-parent or not. The variable *College parents* take value 1, if at least one parent has a degree in higher education.

Table 5, Column (1), shows that (similar to Table 4) the curriculum change increased the likelihood of graduating with *Nature/Tech* more strongly for students with college-educated parents. Overall the treatment effect is 4.6 percentage points larger (significant at the 1-percent level) and the pattern is very similar for women and men. However, as opposed to the previous table, there are no differential long-run effects of the policy based on whether parents are college-educated or not.

To summarize, the curriculum change increased the likelihood of graduating secondary school with *Nature/Tech* more strongly for students with college-educated or with STEM-parents. In terms of longer-run outcomes (STEM bachelor or master), there is no differential effect of the policy based on whether parents are college-educated or STEM-educated with the exception of having STEM-educated parents for women. In the latter case, the curriculum change actually had a significantly negative effect on the likelihood of STEM bachelor or master for women with STEM-parents.

Why would the policy change have positive effects and particularly positive effects for students with college-educated and STEM-educated parents? These children tend to be more academically able and thus have lower effort costs in making use of the opportunity to graduate in the *Nature/Tech* field. Moreover, as discussed above, graduating in the *Nature/Tech* field is more prestigious and

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[14] They should also be better able to help their children in terms of tutoring, so the (more) negative treatment effects for students with STEM parents is likely to be an underestimate of the pure information effect (which is partially made up for by STEM parents directly helping their children in terms of material).

leads to better quantitative skills with likely direct benefits in the labor market (and possibly also in the marriage market) even without additional college degree. These two facts combined may explain, why the curriculum change led to a particularly strong increase in *Nature/Tech* for students with college/STEM-parents.

In terms of longer-run effects on the other hand, parents with STEM degree are particularly aware that after the curriculum change the level of preparedness for a STEM-degree at university has deteriorated leading to increased costs of obtaining such a degree and a higher risk of drop-out or graduating with worse grades. These parents are likely to signal this to their children. Interestingly, women appear to respond to this negative signal more strongly than men. This is consistent with evidence from the experimental literature that men have higher self-confidence (Morin (2015), Preckel et al. (2008), Niederle and Versterlund (2007)), and are less sensitive to their surroundings when choosing a major (Mouganie and Wang (2019), Cools et al. (2019)).

5.2 Longer-Run Benefits from Choosing *Nature/Tech*

The question that remains is, if it was beneficial for women, especially women with a STEM parent, to choose *Nature/Tech* in high school, despite not being more likely (or even less likely) to obtain a STEM bachelor or master at university. As discussed above, there may be benefits to obtaining a *Nature/Tech* degree in high school even without continuing with a STEM major at university.

To investigate this question, we look at the longer-run effects of the policy change until students are in their late twenties (age 29) and analyze the effect of the policy change on individuals' income, how much study delay they had (how many months did students exceed nominal duration of their studies), whether they had a partner/spouse and the characteristics of the partner, whether they had children and the age of first time parenthood.

[Table 6 here]

In Table 6 we present results for these longer-run variables of interest. Again, we estimate effects overall and for the subsamples split by gender and household income. While we generally do not find significant effects in terms of graduation delay, likelihood of obtaining a bachelor or master degree, income, likelihood of having a partner/spouse or children, we do find strong and significant effect on the likelihood of having a partner with a *Nature/Tech* degree. The policy change led to an increase in the likelihood of having a partner with *Nature/Tech* for women and men (by 2 and 3.1 percentage points, respectively, significant at the 1-percent level) and also high and low income students (by 2 and 2.7 percentage points, respectively, again significant at the 1-

percent level).[15] Since graduating with a *Nature/Tech* degree is prestigious and valued in the labor market, one may interpret this as a positive longer-run effect of the policy. However, given that the students of our cohorts are still relatively young, it is difficult to say whether the increase in their own and their partner's likelihood of having a *Nature/Tech* degree will ultimately materialize in terms of higher own and household earnings.

5.2.1 Longer-Run Benefits for Students with STEM Parents

The question of longer-run outcomes is particularly interesting for women with STEM-educated parents, since they were the ones to increase the take-up of *Nature/Tech* particularly strongly, to then actually decrease the likelihood of a STEM bachelor or master degree.

[Table 7 here]

Table 7 shows that the curriculum change led to a significant increase in the income of women with a STEM-parent, while it did not increase the income of women without STEM parents (the differences is significant at the 5-percent level). Also, the policy led to an increase in the likelihood of being married by age 29 of 5 percentage points, while it did not increase the likelihood of women without STEM parents (again the difference is significant at the 5-percent level). In terms of likelihood of children, the policy actually decreased the likelihood of women without STEM parent, but did not have any effect on women with STEM parents. None of the long-run outcomes of men are affected (neither for men with nor without STEM parents).

5.3 Classroom Composition

In this section, we investigate further potential reasons for why women and students from privileged backgrounds responded to the policy particularly strongy in terms of increasing the likelihood to choose the *Nature/Tech* field. Apart from the fact that the *Nature/Tech* degree provides the option value to study any major at university and having more quantitative skills and a more prestigious secondary school degree, may be related to network effects. By choosing *Nature/Tech*, you obtain a larger network of peers in your school who also chose *Nature/Tech*, which certainly contributed to our finding that the policy increased the likelihood overall and by subgroups (gender and SES) of having a partner with a *Nature/Tech* degree.

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[15] Apart from this high income students are somewhat more likely to obtain a master in response to the policy and men are more likely to have a partner with STEM bachelor and to have a partner with somewhat lower income.

[Table 8 here]

In Table 8, we analyze how the effect of the policy change on the different subgroups differs depending on the predetermined share of females and high SES students in the *Nature/Tech* field (based on the fraction of women and high SES students in *Nature/Tech* in a given school in the cohort before the cohorts of interest to prevent endogeneity).

In Table 8, Panel A, we see that the treatment effect of the curriculum change does not depend on the share of women in *Nature/Tech* prior to the reform. Interestingly, also women are not more likely to respond to the policy and increase the likelihood of choosing *Nature/Tech* if there was a higher fraction of women in the field already in the past.

According to Panel B on the other hand, it can be seen that the predetermined share of high income students is important. The treatment effect is amplified for women and students from a high income households. A school with an above median predetermined share of high income students in *Nature/Tech* leads to a treatment effect of the curriculum change that is 2.2 percentage points larger for women (the difference is significant at the 1-percent level). The treatment effect is also larger (by 1.6 percentage points, significant at 10 percent) for high income students, if the school had an above median share of high income students in the field in prior cohorts. This gives reason to suspect that there is a networking (and possibly marriage market) effect for women and high income students.

6 Concluding Remarks

Since future economic growth can primarily be expected in the fields of science, technology, engineering and mathematics (STEM) (OECD, 2010), the demand for STEM graduates worldwide is high and rising. Nevertheless, a relatively small fraction of Bachelor degrees were awarded in STEM fields (e.g. only 18 percent in 2016 in the U.S. according to the U.S. Department of Education (2017)). Moreover, women, minorities and students from less privileged families are underrepresented in the STEM field. One particular focus among policy makers is therefore to enact policies aimed at tapping the unused potential, especially among the underrepresented groups, to increase the supply of STEM graduates.

One such policy has been enacted in the Netherlands in 2007. The Dutch government changed the secondary school curriculum, reducing the number of mandatory STEM hours in the STEM field, to attract more students, in particular from underrepresented groups, to this area. The STEM field in secondary school (*Nature/Tech*) plays a critical role in that graduating with this specialization is the prerequisite for choosing a STEM major at university. This holds for students assigned to the academic track in high school (required to enrol in a research university), as well as for students assigned to the technical track (necessary for enrolling in a university of applied sciences). To increase the accessibility and attractiveness of *Nature/Tech* in secondary school, the Dutch government lowered the work load in terms of field-specific course hours starting in 2007, and the reduction was particularly strong in the academic track. We make use of the differential reduction in STEM hours in the two tracks by employing a difference-in-differences design combined with Dutch administrative data to analyze the short-, medium- and long-run effects of the curriculum change and shed light on the underlying mechanisms.

Our main findings are as follows: First, investigating the short-run effect of the reduction in mandatory STEM hours, we find that the policy increased the likelihood of specializing in *Nature/Tech* by 11 percentage points and thus substantially increased the fraction of students satisfying the formal requirements to enrol in a STEM major at university.

Second, we find stronger direct effects of the policy change on female than male students. The policy thereby reduced the gender gap by nearly 7 percentage points. In terms of socioeconomic background on the other hand, the policy increased the gap between low- and high-income students, since the treatment effect was substantially stronger for students from more privileged households. Thus, in the short-run, the policy (partially) met the intended goals: Overall a substantially larger fraction of students met the formal requirement to enrol in a STEM field at university and the gender gap decreased. On the other hand, the socioeconomic status gap increased somewhat.

Third, the effects we find in the medium and longer-run paint a different picture. Despite the fact that the fraction of students satisfying the formal requirements for STEM at university went up substantially, the likelihood of enrolling into or graduating with a STEM bachelor or master remains unchanged.

Fourth, while the policy led to a slight increase in terms of male students graduating with a STEM degree, the effect on women is significantly smaller and, more specifically, there is no increase (or even a slight decrease) for women graduating with a STEM degree. Thus in the longer-run the policy led to a widening of the existing gender gap in STEM graduates, contrary to what was intended. Also the socioeconomic status gap increased in response to the policy.

Fifth, we investigate the underlying mechanisms behind the observed short-run and long-run effects of the policy. In the short-run, the reduction in mandatory STEM hours (in particular in math and physics) in the STEM field *Nature/Tech* implied an important decrease in the effort costs of graduating from high school in *Nature/Tech*, which not only has the option value of studying any major at university (including STEM), but also is a prestigious degree per se with benefits in the labor and marriage market. Thus, it is not surprising that in response to the policy, the fraction of students choosing *Nature/Tech* in secondary school went up, even if the likelihood of obtaining a STEM bachelor or master did not go up in the longer-run. What is more surprising is that women's likelihood of choosing *Nature/Tech* went up particularly strongly, but the likelihood of a STEM bachelor or master went down relative to men. Our results suggest that this is linked to the fact that after the curriculum change, students acquire less STEM-specific knowledge and are less prepared for a STEM major at university. In fact, while women (and men) with STEM parents respond particularly strongly to the policy in increasing their *Nature/Tech* choice, women with STEM parents actually *reduce* their likelihood of obtaining at STEM bachelor or major (compared to women without STEM parents). The same is not true for students with college-educated parents or for men, consistent with STEM parents being particularly aware of the lack of preparedness and signalling this to their children, while women who tend to be more risk averse about worse grades and risk of drop-out are the ones who respond to their parents signals.

To conclude, in the long-run, policy was ineffective in terms of increasing the overall fraction of students with STEM majors. Moreover, students entering the STEM major at university will have a weaker STEM background due to the less intensive STEM courses in secondary school. Lastly, the composition of the group of STEM graduates changed towards more male students and students from wealthier households at the expense of female students (with STEM parents) and students from less privileged households. The policy's impact thus go against the explicit goals of the policy of increasing the fraction of STEM graduates overall and for previously underrepresented groups and against the idea of equality of opportunity of education.

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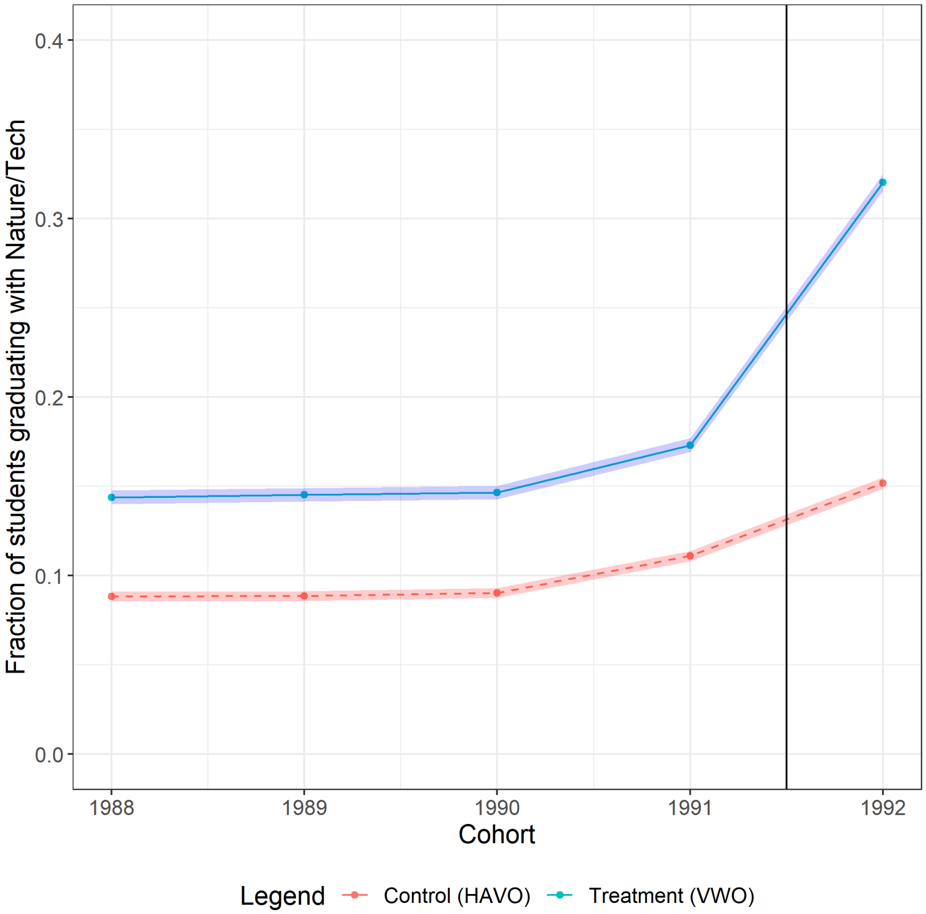
Figures and Tables

Table 1: Population Summary Statistics

	VWO			HAVO		
	Younger Mean (SD)	Older Mean (SD)	Diff (p-value)	Younger Mean (SD)	Older Mean (SD)	Diff (p-value)
Female	.543	.542	.001	.514	.518	−.004
	(.498)	(.498)	(.731)	(.5)	(.5)	(.305)
Birth Month	6.356	6.368	−.012	6.532	6.566	−.034
	(3.47)	(3.469)	(.612)	(3.45)	(3.45)	(.131)
Siblings	1.682	1.694	−.012	1.76	1.77	−.01
	(1.098)	(1.101)	(.051)	(1.24)	(1.222)	(.189)
Two Parents HH	.772	.767	.005	.723	.717	−.006
	(.419)	(.423)	(.128)	(.448)	(.45)	(.049)
Migration Background	.170	.172	−.002	.176	.174	.002
	(.376)	(.377)	(.397)	(.381)	(.379)	(.485)
Non Western Migration	.091	.093	−.002	.114	.109	.005
	(.287)	(.291)	(.258)	(.318)	(.312)	(.019)
Both Parents Foreign	.079	.081	−.002	.100	.099	.001
	(.27)	(.274)	(.313)	(.264)	(.298)	(.283)
Observations	38,191	37,625		46,264	45,701	
HH Income Percentile	78.26	78.04	.22	73.07	73.34	−.27
	(20.449)	(20.64)	(.289)	(21.79)	(21.6)	(.118)
Low Income	.161	.165	−.004	.229	.224	.005
	(.368)	(.372)	(.107)	(.42)	(.417)	(.100)
Observations	37,242	36,660		45,043	44,518	
Parent with College	.347	.331	.016	.239	.235	.004
	(.476)	(.47)	(<.001)	(.426)	(.424)	(.323)
Parent with STEM	.114	.114	<.001	.075	.072	.003
	(.318)	(.318)	(.998)	(.258)	(.264)	(.111)
Observations	26,701	25,723		31,220	30,176	

Note: HH: Household

Figure 1: Fraction of the students graduating high school with Nature/Tech by birth cohort



Note: The y-axis displays the fraction of students who graduated with the Nature/Tech field in high school. The x-axis displays the birth cohort. The policy change only applies to those born in birth cohort 1992. However, due to retainers some students born in birth cohort 1991 also chose a field of graduation after the policy change. The shaded areas indicate 95 percent confidence intervals.

Table 2: Shortrun effects: Graduating secondary school with Nature/Tech

	Nature/Tech Field Completion			
	Main		Placebo	
	No controls	Controls	No controls	Controls
	(1)	(2)	(3)	(4)
Panel A: All students				
Treatment	$.108^{***}$	$.108^{***}$	$-.0005$	$-.001$
	(.004)	(.004)	(.003)	(.003)
Observations	154,042	154,042	141,719	141,719
Panel B: By gender				
Treatment **for women**	$.137^{***}$	$.137^{***}$	$-.0004$	$-.001$
	(.004)	(.004)	(.003)	(.003)
Observations	81,340	81,340	74,890	74,890
Treatment **for men**	$.075^{***}$	$.074^{***}$	$-.001$	$-.002$
	(.004)	(.004)	(.006)	(.006)
Observations	72,702	72,702	66,829	66,829
p-value of the difference		<.0001		.978
Panel C: By household income				
Treatment **for low income households**	$.070^{***}$	$.074^{***}$	$-.004$	$-.004$
	(.009)	(.009)	(.007)	(.007)
Observations	30,211	30,211	28,530	28,530
Treatment **for high income households**	$.114^{***}$	$.115^{***}$	$-.0004$	$-.0004$
	(.004)	(.004)	(.004)	(.004)
Observations	123,831	123,831	113,189	113,189
p-value of the difference		<.0001		.617
Control variables	NO	YES	NO	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. The dependent variable is an indicator variable which is 1 if the student graduated secondary school with the Nature/Tech field and 0 otherwise. Treatment shows the point estimate of β_1, the DID estimator. In columns 1 and 2, the cohorts of interest are analyzed. In columns 3 and 4, the two cohorts before the cohorts of interest are analyzed. The regressions in the odd columns only include the three difference-in-differences indicators, while the regressions in the even columns include control variables on the individual level.

Table 3: Longerrun effects: Graduating with a STEM bachelor or master degree

	STEM Degree Completion			
	STEM Bachelor		STEM Master	
	Main	Placebo	Main	Placebo
	(1)	(2)	(3)	(4)
Panel A: All students				
Treatment	.005	.0004	.002	−.003
	(.003)	(.003)	(.003)	(.003)
Observations	154,042	141,719	154,042	141,719
Panel B: By gender				
Treatment **for women**	-.003	.001	−.005	.0003
	(.004)	(.004)	(.004)	(.004)
Observations	81,340	74,890	81,340	74,890
Treatment **for men**	.014***	−.0003	.010**	−.006
	(.005)	(.005)	(.004)	(.004)
Observations	72,702	66,829	72,702	66,829
p-value of the difference	.004	.960	.002	.318
Panel C: By household income				
Treatment **for low income households**	−.007	−.001	−.012*	−.004
	(.007)	(.007)	(.006)	(.007)
Observations	30,211	28,530	30,211	28,530
Treatment **for high income households**	.007**	.001	.005	−.002
	(.003)	(.003)	(.003)	(.003)
Observations	123,831	113,189	123,831	113,189
p-value of the difference	.080	.803	.010	.775
Control variables	YES	YES	YES	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. In columns 1 and 2, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Bachelor and 0 otherwise. In columns 3 and 4, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Master and 0 otherwise. Treatment shows the point estimate of β_1, the DID estimator. In the odd columns, the cohorts of interest are analyzed. In the even columns, the two cohorts before the cohorts of interest are compared as a test for pretrends. All regressions include control variables on the individual level.

Table 4: Parents with a STEM degree

	Main Cohorts		
	Nature/Tech (1)	STEM Bachelor (2)	STEM Master (3)
Panel A: All students			
Treatment x STEM parents	$.073^{***}$	$-.010$	$-.012$
	(.018)	(.012)	(.011)
Treatment	$.099^{***}$	.004	.003
	(.005)	(.004)	(.003)
Observations	104,879	104,879	104,879
Panel B1: Women			
Treatment x STEM parents	$.075^{***}$	$-.038^{***}$	$-.024^{*}$
	(.021)	(.017)	(.015)
Treatment	$.128^{***}$	$-.002$	$-.005$
	(.005)	(.005)	(.005)
Observations	55,265	55,265	55,265
Panel B2: Men			
Treatment x STEM parents	$.059^{**}$	.018	.002
	(.029)	(.018)	(.016)
Treatment	$.066^{***}$	$.012^{**}$	$.011^{**}$
	(.008)	(.006)	(.005)
Observations	49,614	49,614	49,614
Control variables	YES	YES	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. In column 1, the dependent variable is an indicator variable which is 1 if the student graduated secondary school with the Nature/Tech field. In column 2, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Bachelor and 0 otherwise. In column 3, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Master and 0 otherwise. Treatment shows the point estimate of β_1, the DID estimator. Treatment x STEM parents is a triple interaction term that is 1 if an individual is treated and has at least one parent with a college degree in a STEM field. All regressions include control variables on the individual level.

Table 5: Parents with a College degree

	Main Cohorts		
	Nature/Tech (1)	STEM Bachelor (2)	STEM Master (3)
Panel A: All students			
Treatment x College parents	.046***	.002	.004
	(.011)	(.008)	(.007)
Treatment	.092***	.002	−.001
	(.006)	(.004)	(.004)
Observations	104,879	104,879	104,879
Panel B1: Women			
Treatment x College parents	.042***	−.004	−.007
	(.012)	(.011)	(.010)
Treatment	.123***	−.006	−.006
	(.006)	(.006)	(.005)
Observations	55,265	55,265	55,265
Panel B2: Men			
Treatment x College parents	.051***	.008	.015
	(.018)	(.012)	(.011)
Treatment	.056***	.011	.006
	(.010)	(.007)	(.006)
Observations	49,614	49,614	49,614
Control variables	YES	YES	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. In column 1, the dependent variable is an indicator variable which is 1 if the student graduated secondary school with the Nature/Tech field. In column 2, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Bachelor and 0 otherwise. In column 3, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Master and 0 otherwise. Treatment shows the point estimate of β_1, the DID estimator. Treatment x College parents is a triple interaction term that is 1 if an individual is treated and has at least one parent with a college degree. All regressions include control variables on the individual level.

Table 6: Longer run Treatment effect by subgroup

	Treatment			
	Females	Males	Low Income	High Income
	(1)	(2)	(3)	(4)
Graduation delay (months)	.500	−.317	−.108	.139
	(.350)	(.396)	(.641)	(.289)
Bachelor	−.001	.001	.007	−.003
	(.005)	(.006)	(.010)	(.004)
Master	.010	.008	−.010	.013***
	(.006)	(.006)	(.010)	(.005)
Personal Income	−.012	.016	−.007	.004
	(.021)	(.025)	(.043)	(.017)
Partner	.006	.007	.010	.006
	(.005)	(.006)	(.010)	(.004)
Married	.002	.005	.009	.002
	(.006)	(.005)	(.009)	(.005)
Child(ren)	−.007	.001	.006	−.004
	(.006)	(.005)	(.009)	(.004)
Partner Personal Income	.011	−.059*	.021	−.003
	(.021)	(.030)	(.047)	(.004)
Partner Nature/Tech	.020***	.031***	.020***	.027***
	(.004)	(.005)	(.007)	(.003)
Partner STEM Bachelor	.0002	.017**	.005	.008
	(.007)	(.007)	(.011)	(.006)
Partner STEM Master	.001	.005	.004	.002
	(.003)	(.003)	(.005)	(.002)
Observations	81,335	72,739	30,222	123,852
Controls	YES	YES	YES	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. Columns 1 and 2 show the effect of the treatment on women and men, respectively. Columns 3 and 4 show the effect of the treatment on students from low- and high income households, respectively. The rows indicate the different dependent variables of interest. The coefficients show the point estimate of β_1, the DID estimator. All regressions include control variables on the individual level.

Table 7: Longer run effects for women with parental STEM education

	Parental Background Women			**Parental Background Men**		
	STEM (1)	no STEM (2)	Diff (3)	STEM (4)	no STEM (5)	Diff (6)
Income	.218**	−.042	.253**	−.061	−.005	−.073
	(.093)	(.027)	(.094)	(.114)	(.033)	(.119)
Married	.050*	.002	.054**	.010	.003	.011
	(.026)	(.026)	(.027)	(.021)	(.007)	(.023)
Children	.037	−.013*	.047*	.019	.001	.013
	(.025)	(.008)	(.026)	(.019)	(.006)	(.020)
Observations	4,329	48,764	53,093	4,259	43,311	47,570
Control variables	YES	YES	YES	YES	YES	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. In column 1, the dependent variable is the logarithmic gross income at age 29. In column 2, the dependent variable is an indicator variable which is 1 if the individual got married by age 29 and 0 otherwise. In column 3, the dependent variable is an indicator variable which is 1 if the student had at least one child by age 29 and 0 otherwise. Treatment shows the point estimate of β_1, the DID estimator. Treatment x STEM parents is 1 if an individual is treated and has at least one parent with a college degree in a STEM field. All regressions include control variables on the individual level.

Table 8: Classroom composition

	Nature/Tech			
	Females	Males	Low Income	High Income
	(1)	(2)	(3)	(4)
Panel A: More women in Nature/Tech				
Treatment x Share of Women	.002	.003	$-.011$	.004
	(.009)	(.015)	(.019)	(.009)
Treatment	.137***	.070***	.078***	.112***
	(.007)	(.011)	(.014)	(.007)
Observations	77,976	70,213	29,083	119,106
Panel B: More high income students in Nature/Tech				
Treatment x Share of High Income	.022***	.005	$-.025$	.016*
	(.009)	(.014)	(.018)	(.009)
Treatment	.128***	.074***	.087***	.109***
	(.006)	(.010)	(.013)	(.006)
Observations	77,976	70,213	29,083	119,106
Control variables	YES	YES	YES	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. The dependent variable is an indicator variable which is 1 if the student graduated secondary school with the Nature/Tech field. Columns 1 and 2 show the effect of the treatment on women and men, respectively. Columns 3 and 4 show the effect of the treatment on students from low- and high income households, respectively. Treatment shows the point estimate of β_1, the DID estimator. Treatment x Share of Women is 1 if an individual is treated and graduated from a secondary school that had a higher than median predetermined share of female students graduating with the Nature/Tech field. Treatment x Share of High Income is 1 if an individual is treated and graduated from a secondary school that had a higher than median predetermined share of high income students graduating with the Nature/Tech field. All regressions include control variables on the individual level.

ONLINE APPENDIX

The Long-run Effects of STEM-Hours in High School Evidence from Dutch Administrative Data

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Table A.1: STEM fields according to ISCED (2011)

STEM Fields	Non-STEM Fields
Sciences (life, physical, and computing) Technology (manufacturing, and processing) Engineering (including engineering trades and civil engineering) Mathematics (including operations research, numerical analysis, actuarial science, and statistics)	All other fields

Table A.2: Second Phase of secondary school before and after the policy change

	HAVO			VWO		
	Old	New	Δ	Old	New	Δ
Compulsory courses						
Dutch	400	400	0	480	480	0
English	360	360	0	400	400	0
Third Language	160	0	-160	320	480	+160
Other (P.E. etc)	560	360	-200	760	560	-200
Nature/Tech						
Physics	440	400	-40	560	480	-80
Chemistry	280	320	+40	520	440	-80
Math B	440	360	-80	760	600	-160
Electives	560	1,000	+440	1,000	1,360	+360
Other fields						
Field courses	1,160	1,040	-120	1,840	1,440	-400
Electives	560	1,040	+480	1,000	1,440	+440
Total	3,200	3,200	0	4,800	4,800	0

Table A.3: Heterogeneous effects by migration background

	Degree Completion					
	Nature/Tech		STEM Bachelor		STEM Master	
	Main	Placebo	Main	Placebo	Main	Placebo
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: All students						
Treatment	$.108^{***}$	$-.001$	.005	.0004	.002	$-.003$
	(.004)	(.003)	(.003)	(.003)	(.003)	(.003)
Observations	154,042	141,719	154,042	141,719	154,042	141,719
Panel D: By migration background						
Treatment **with migration background**	$.113^{***}$	$-.002$	.001	$-.004$	.003	$-.006$
	(.009)	(.008)	(.008)	(.009)	(.007)	(.008)
Observations	24,396	22,459	24,396	22,459	24,396	22,459
Treatment **without migration background**	$.107^{***}$	$-.0004$	$.006^{*}$	.002	.002	$-.002$
	(.004)	(.004)	(.003)	(.004)	(.003)	(.003)
Observations	129,646	119,260	129,646	119,260	129,646	119,260
p-value of the difference	.617	.739	.436	.436	.803	.453
Control variables	YES	YES	YES	YES	YES	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. In columns 1 and 2, the dependent variable is an indicator variable which is 1 if the student graduated secondary school with Nature/Tech field and 0 otherwise. In columns 3 and 4, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Bachelor and 0 otherwise. In columns 5 and 6, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Master and 0 otherwise. Treatment shows the point estimate of β_1, the DID estimator. In the odd columns, the cohorts of interest are analyzed. In the even columns, the two cohorts before the cohorts of interest are compared as a test for pretrends. All regressions include control variables on the individual level.

Table A.4: Parents with a STEM degree: Placebo cohorts

	Placebo cohorts		
	Nature/Tech (1)	STEM Bachelor (2)	STEM Master (3)
Panel A: All students			
Treatment x STEM parents	.013	−.005	−.003
	(.018)	(.014)	(.011)
Treatment	−.002	.001	−.001
	(.004)	(.004)	(.004)
Observations	92,522	92,522	92,522
Panel B1: Women			
Treatment x STEM parents	−.005	−.013	−.0003
	(.015)	(.018)	(.016)
Treatment	−.003	.002	.001
	(.003)	(.006)	(.005)
Observations	48,634	48,634	48,634
Panel B2: Men			
Treatment x STEM parents	.032	.003	−.004
	(.031)	(.020)	(.017)
Treatment	.0001	.0003	−.004
	(.008)	(.006)	(.005)
Observations	43,888	43,888	43,888
Control variables	YES	YES	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. In column 1, the dependent variable is an indicator variable which is 1 if the student graduated secondary school with the Nature/Tech field. In column 2, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Bachelor and 0 otherwise. In column 3, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Master and 0 otherwise. Treatment shows the point estimate of β_1, the DID estimator. Treatment x STEM parents is a triple interaction term that is 1 if an individual is 'treated' and has at least one parent with a college degree in a STEM field. All regressions include control variables on the individual level.

Table A.5: Parents with a College degree: Placebo cohorts

	Placebo cohorts		
	Nature/Tech (1)	STEM Bachelor (2)	STEM Master (3)
Panel A: All students			
Treatment x College parents	.001	−.008	−.012
	(.010)	(.009)	(.008)
Treatment	−.003	.003	.002
	(.005)	(.005)	(.004)
Observations	92,522	92,522	92,522
Panel B1: Women			
Treatment x College parents	.007	−.011	−.015
	(.008)	(.012)	(.011)
Treatment	−.006	.003	.006
	(.004)	(.006)	(.005)
Observations	48,634	48,634	48,634
Panel B2: Men			
Treatment x College parents	.009	−.003	−.008
	(.017)	(.013)	(.011)
Treatment	−.001	.001	−.002
	(.009)	(.007)	(.006)
Observations	43,888	43,888	43,888
Control variables	YES	YES	YES

Notes: * denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. Standard errors are displayed in brackets and are robust. In column 1, the dependent variable is an indicator variable which is 1 if the student graduated secondary school with the Nature/Tech field. In column 2, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Bachelor and 0 otherwise. In column 3, the dependent variable is an indicator variable which is 1 if the student graduated with a STEM Master and 0 otherwise. Treatment shows the point estimate of β_1, the DID estimator. Treatment x College parents is a triple interaction term that is 1 if an individual is 'treated' and has at least one parent with a college degree. All regressions include control variables on the individual level.