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Peer Effects in Vocational Education and Training

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Vocational Education and Training (VET) programs are prevalent in a European context, but often struggle with drop-out rates that exceed those of general upper-secondary education. Using Danish administrative data, we study the effects of reform-induced reductions in shares of VET students who did not pass their lower secondary final exams on passing GPA VET students. We find that passing students have a higher probability of remaining enrolled in VET after the first year of studies when entering a VET school with a higher share of below-passing peers. Studying outside options, we find that students become less likely to drop out of education entirely. The results are consistent with models of peer effects in which particularly unmotivated students become points of comparison for their peers, increasing their motivation and likelihood of remaining enrolled.

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Abstract

Vocational Education and Training (VET) programs are prevalent in a European context, but often struggle with drop-out rates that exceed those of general upper-secondary education. Using Danish administrative data, we study the effects of reform-induced reductions in shares of VET students who did not pass their lower secondary final exams on passing GPA VET students. We find that passing students have a higher probability of remaining enrolled in VET after the first year of studies when entering a VET school with a higher share of below-passing peers. Studying outside options, we find that students become less likely to drop out of education entirely. The results are consistent with models of peer effects in which particularly unmotivated students become points of comparison for their peers, increasing their motivation and likelihood of remaining enrolled. *JEL Codes: I21, I28.*

1 Introduction

A crucial social policy role of education is to help smooth the transition from formal schooling to gainful employment and financial independence. Vocational Education and Training (VET) programs have been widely used to help facilitate this transition. VET graduates often have a smoother transition into employment and (initial) higher wages than their academically educated peers (Hanushek et al. 2017; OECD 2010; Ryan 2001; Wolter and Ryan 2011; Brunner, Dougherty, and Ross 2023).[1] They also account for a substantial share of all upper secondary education, particularly in European countries where, for example, 50 percent of upper secondary students enroll in vocational programs in Germany, 19 percent in Denmark, and 70 percent in Austria.[2] Recently, both the United States and England have initiated large reform programs with the aim of developing and helping more students enter VET and apprenticeships that are a common component of the VET programs (Dougherty and Harbaugh Macdonald 2020; McNally 2020).

Despite increased policy focus, upper secondary VET programs have had high dropout rates that can be more than twice those of general upper secondary education (OECD 2010, p. 37).[3] For example, between 20 and 25 percent of initiated VET apprenticeship contracts were terminated before completion between 1990-2011 in Germany, with rates

[1] Recent evidence from the United States and Finland even suggests that students on the margin between vocational and academically oriented general upper secondary education may have higher graduation rates and long-run earnings when entering VET (Brunner, Dougherty, and Ross 2023; Silliman and Virtanen 2022).

[2] The enrollment numbers are collected from Hippach-Schneider and Huismann (2019), table 7, Andersen and Helms (2019), p. 17, and Cedefop and ibw Austria (2019). Appendix (OA) III provides further introduction to international comparisons of VET programs.

[3] There seemingly exists no comprehensive statistics across countries on upper secondary VET program drop out, partly because these programs are often conflated with general upper secondary education in national statistics (Bôhn and Deutscher 2022; Cedefop 2016b). As a result, the statistics we list are not directly comparable, but all relate to dropout from VET programs.

as high as 50 percent in some professions (BIBB 2013, table A4.7-2; Cedefop 2016a), 24 percent of French and 20.5 percent of Dutch VET students had not completed their program when leaving them in 2004 and 2005 Cedefop 2016a, pp. 52. More than 40 percent of students drop out of Danish VET programs within five years after enrolling (Statistics Denmark 2021).[4] Reducing dropout rates from VET programs is a core concern in supporting students at risk of leaving the education system without degrees or outlook to stable employment (Cedefop 2016a).

A growing literature, surveyed by Sacerdote (2014), has shown that peers can substantially affect individuals' education achievement, attainment, and subsequent labor market performance. Despite the persistent interest in understanding how social networks and interactions affect individual outcomes, there is a lack of knowledge of how these effects operate in workforce-focused education environments such as VET. This paper uses a 2015 VET reform in Denmark that reduced the share of VET students who had not passed Danish and Mathematics, to investigate whether changing the composition of peers in VET programs affects dropout rates. In doing so, we provide some of the first evidence of these effects, focusing on the impact of changes in the share of academically lower-achieving students on the probability of dropping out of school among higher-achieving students.

In Lazear's (2001) 'bad apple model,' having disruptive peers can lead to the decreased achievement of the less disruptive students when teacher effort and learning time is directed towards minimizing disruptions. The bad apple type of peer effects has gathered wide support in studies of potentially disruptive and low-GPA peers in academically oriented learning environments. Carrell, Hoekstra, and Kuka (2018) find negative long-run

[4] See also figure (OA) II.2.

income effects from having more peers who have experienced domestic violence in Florida elementary schools, and Lavy, Paserman, and Schlosser (2012) show that having more low-GPA peers in classes lowers learning outcomes for other students and possibly increases in-class violence incidences in Israeli schools.[5] In a well-identified study of peer effects using composition changes induced by migration from Hurricane Katrina, Imberman, Kugler, and Sacerdote (2012) shows that having more low-GPA peers may harm students' learning in academic learning environments. A policy recommendation arising from these studies is to separate low-ability students from higher-ability students, potentially for the benefit of both groups.

In contrast to the bad apple hypothesis, alternative "big fish in a small pond" effects could point to potential positive effects from interacting with challenged peers Marsh (1987). This theory assumes that having less attentive or worse-performing peers motivates better-performing students, for example, by increasing their relative ranking within the learning environment. These big-fish effects have been shown to exist, e.g., in US middle schools (Elsner and Isphording 2017), at university (Elsner, Isphording, and Zölitz 2021), and in English lower secondary schools (Murphy and Weinhardt 2020). These studies point towards either zero or even adverse effects of removing students who, by their relative characteristics, behavior, or performance, act as reference points for students performing better in the programs.

We study the effects of the presence of lower-achieving peers on the likelihood that

[5] Duflo, Dupas, and Kremer (2011) find positive effects from tracking both low-GPA students and higher-GPA students in Kenyan primary schools. Tracking undergraduate Economics students into tutorial groups, and Booij, Leuven, and Oosterbeek (2017) find positive effects on low-GPA students and middle and high-GPA students from separating the low-GPA students in their groups. In contrast, Garlick (2018) finds that sorting students by GPA when assigning dorm-mates in a South African college leads to lower outcomes for low-GPA students and no benefit for high-GPA students.

other students' remained enrolled in the workforce-oriented VET programs. To do this, we use Danish administrative data on 2009-2016 VET cohorts where the latter two cohorts were affected by the 2015 Danish VET reform. The reform aimed to decrease dropout rates and increase the learning and well-being of students in the Danish VET programs. A key tool to reach those goals was introducing a GPA requirement such that VET applicants had to pass Danish and Mathematics in final lower secondary exams to be eligible to enroll in their VET program choice. Before the reform, all applicants were admitted regardless of their GPA if their program choice had sufficient open spots. We refer to those students who did not pass either or both of Danish and Mathematics subjects in lower secondary education as below-passing students and students who passed both as above-passing. Below-passing students could still be admitted to the VET program if they took and passed a supplementary test in the failed subject(s) but would otherwise not be admitted. Because some VET schools tended to have higher shares of below-passing students entering from lower secondary education, the reform's effect on student compositions varied across schools, as the share of below-passing students declined more at schools with higher pre-reform shares. By removing below-passing peers, the reform allows us to study which is more important of the theoretical bad-apple and big-fish effects.

The empirical strategy uses the institution-specific shock induced by the reform as an instrument for shares of below-passing students in regression models that control for institution and time-fixed effects to account for typical student self-selection. In effect, this combines a within-institution over time variation identification strategy pioneered by Hoxby (2000)[6] with exogenous shocks to the composition of the education environment

[6]Recent peer effects studies based on within-institution over time variation include, e.g., Anelli and Peri (2019), Brenøe and Zölitz (2020), and Feld and Zölitz (2017).

(Angrist and Lang 2004; Imberman, Kugler, and Sacerdote 2012; Sacerdote 2014). Rather than including all VET students in our sample, we only estimate the models using a sample of above-passing students to avoid conflating post-reform selection among below-passing students with peer effect estimates. The model focuses on the effects of pre-determined contextual characteristics of students and can be viewed as a reduced form of more general social interaction models that might aim to disentangle within-program interaction effects from contextual effects (Manski 1993; Blume et al. 2015). Unfortunately, we have not been able to obtain data that could provide further evidence on, e.g., friendship network formations or teacher interactions that might be part of the mechanisms driving the results.

The primary outcome we study is whether the above-passing student enters the main VET program one year after initial enrollment in an introductory VET program. The one-year threshold is essential because Danish VET students must find an apprenticeship with a firm (or another type of organization) to transition from the first-year introductory program to the apprenticeship-based main program and graduate. Nearly all dropouts happen during this transition. Historically, almost 40 percent of students who finish the introductory program have not entered a main program 3 and 6 months after graduating from the introductory program (Groes, Madsen, and Sandoy 2021; Ministry of Children and Education 2022). This makes the one-year Main program enrollment the most relevant threshold to study in terms of dropout. The first year is also when students primarily interact with school peers and where peer effects are likely to occur since the main program is primarily based with the employer. The one-year results may also be relevant for understanding the effects on transitions from VET programs to labor markets more generally, as the apprenticeship market strongly resembles a labor market for school graduates where firms have

limited information on student capabilities (Kahn and Lange 2014).

Our results suggest that for students with above-passing GPAs, having a higher share of peers with below-passing GPAs positively affects remaining in VET programs one year after starting VET. However, the effects differ across outcomes. First, above-passing students become slightly less likely to enter the Main program, with IV estimates of 2-3 percentage points per standard deviation increase in the share of below-passing students. The within-institution standard deviation of the share of below-passing students is 3.6 percent of a cohort. If firms see below-passing and above-passing students as substitutes, then having more below-passing students may partly crowd out the above-passing students. We find evidence that this supply effect can explain part of the Main program effect. Second, we find that above-passing peers become 6-9 percent more likely to re-enroll in an Introductory program rather than dropping out entirely, and that a supply-side effect cannot explain this. While it is challenging to compare effects across various settings, it is noteworthy that our estimates are comparable in size to Cattan et al's (2022) estimates for the effect of a standard deviation increase in the share of Norwegian general upper secondary education peers with elite educated parents on the likelihood that a given child enrolls in elite education, between 2.2 and 4.4 percentage points.

The empirical strategy relies on the reform shock instrument being conditionally independent of unobserved factors given institution and time controls. We test this assumption in several ways. First, we sequentially add additional control variables that previous studies have found to be particularly strong predictors of dropout rates among VET students, including students' own GPA, gender, and parental educational background (Groes, Madsen, and Sandoy 2021; Stratton et al. 2018) and show that main specification estimates

do not change as we add these controls, as they likely would if the conditional exclusion restriction did not hold (Oster 2019). Under the conditional exclusion restriction, the reform instrument should also be unable to predict pre-reform year below-passing shares or outcomes. We test this in a placebo experiment, reassigning the instrument to pre-reform years. This exercise also does not suggest meaningful violations of the exclusion restriction. We also perform a range of other robustness checks that all support the main findings, including removing the smallest and largest institutions, using preliminary test scores to define below-passing and above-passing students instead of final test scores that students may manipulate, creating a continuous rather than binary instrument, and a saturated-IV specification, where the instruments are institution and post-reform indicator interactions. Another concern is that our findings could be driven by a reduced supply of students seeking apprenticeships. We find that changes in the supply of students cannot explain the substantive re-enrollment peer effect.

This paper provides some of the first answers to essential questions about how peer effects play out in VET and Career and Technical Education contexts, focusing on the students who may likely have struggled academically in lower secondary education and thereby contribute to the fast-growing literature on peer effects in education that typically has focused on either lower secondary, general upper secondary, or university settings (Sacerdote 2014). It is most closely linked to two related streams of scholarship. First, we build on a smaller group of studies focused on potentially disruptive students challenged in one or more academic, family or social dimensions, including Carrell, Hoekstra, and Kuka (2018), Lavy, Paserman, and Schlosser (2012), Duflo, Dupas, and Kremer (2011), and Imberman, Kugler, and Sacerdote (2012), that tend to find adverse effects on school

performance, income, and increased violent behavior in the academically oriented learning environment. Second, we contribute to the literature on relative comparisons that include Elsner and Isphording (2017), Elsner, Isphording, and Zölitz (2021), and Murphy and Weinhardt (2020), which typically find positive effects on academic outcomes from being able to compare oneself to less well-performing peers. Our finding of positive effects, particularly among higher-GPA students, is consistent with the latter studies and contrasts with the first. One potential explanation is that many VET programs focus less on academic dimensions of aptitude and more on applied skills, where learning requires substantial learning-by-doing that is less susceptible to disruptions. Another possible explanation is that students with disruptive peers may consider themselves more organized and motivated because they can compare themselves with students who are less so. Interviews we conducted with VET students, firms, and VET and industry interest organizations underscore the importance of this possible explanation. In our interviews, firms and interest organizations emphasized that firms would search for diligent and motivated apprentices. When asked about potentially disruptive peers, students described how those other students were less motivated and more careless and often defined themselves as more motivated in contrast to them. Suppose both firms and students find these characteristics necessary. In that case, students may be less likely to drop out if they think of themselves as more motivated and diligent because they have peers who appear less motivated.

Finally, this paper contributes to the growing literature attempting to disentangle VET schools' functioning in Europe and the US. Dougherty and Harbaugh Macdonald (2020) and Ecton and Dougherty (2022) contains recent overviews on the U.S. Career and Technical Educations and their effects on long-run earnings, and Hanushek et al. (2017), Silliman

and Virtanen (2022), and Kiener et al. (2022) study long-run earnings effects from enrolling in vocational rather than general upper secondary education or enrolling in programs with particular vocational curricula in a European context. This paper shifts attention from the comprehensive effects of VET enrollment to the importance of students' interactions in programs We believe that further studying the effects of social network formations and social interactions in VET and CTE is essential for future research to understand when VET and CTE are most effective in supporting student learning and positively affecting long-run outcomes. We particularly encourage cross-national work that can help pinpoint the importance of the institutional context and student composition.

The following section introduces the Danish education system, emphasizing the upper secondary programs and the 2015 VET reform. Section 3 describes the data used in the analysis, and section 4 describes the empirical strategy and robustness checks. We present the results in section 5 and finally conclude with a discussion of the findings in section 6.

2 Institutional Setting

The structure of Danish VET programs makes it a relevant setting for studying peer effects within VET as it consists of a so-called Dual system similar to those in Germany, Switzerland, and Austria, where students are enrolled in schools throughout their first school year and subsequently must enter apprenticeships at firms and only return to the VET schools for short periods before graduating. This implies that students interact with program peers throughout their first school year while searching for apprenticeship positions, a process reminiscent of the job search for students enrolled in more school-based programs. Findings from this setting may be informative about potential peer effects in VET in countries

with similar dual systems and those with more school-based programs, where graduates must enter the VET labor market for shorter periods or at the end of school-based learning. This section introduces the Danish VET education system and the institutional details surrounding the 2015 VET reform relevant to our study of peer effects.[7]

2.1 The VET Education

Danish Vocational Education and Training begins at the upper secondary level, following mandatory primary and lower secondary education in grades 0 to 9 and an optional 10th grade. Graduating lower secondary education, students can decide either to leave the education system or apply to enter the optional 10th grade, general upper secondary education, or VET.[8] Between 2013 and 2021, 18-19 percent of lower secondary applicants applied to VET (see Figure (OA) II.5). Whereas general upper secondary education lasts between two and three years and prepares the students to pursue tertiary education, VET typically takes about four years to complete and aims to prepare students to enter the labor market, giving access only to a small number of vocationally oriented students to pursue a professional bachelors degree.

The first year in the typical VET program is spent in a school-based introductory program where students are taught fundamentals related to their chosen field together with their program peers. The remaining three years are spent in the Main program, where the student works as an apprentice at a private firm or public organization. We refer to ap-

[7] Appendix (OA) II contains a comprehensive overview of the education system at the primary, lower secondary, and upper secondary education level, and Appendix (OA) III gives a short introduction to VET systems in various other OECD countries.

[8] They can also apply to enter upper secondary preparatory programs aimed at youth not yet prepared to enter upper secondary education, but only an average of 5 percent of lower secondary graduates apply to enter these programs (see Figure (OA) II.5.)

prenticeships in either type of organization as firm apprenticeships throughout the rest of the paper. The apprenticeship is only interrupted briefly when the student returns to the VET school to complete field-specific coursework. Students graduate from the program by taking a comprehensive exam. Based on the time students spend in their apprenticeship, the one-year introductory program spent studying with peers in schools is where we expect peer effects to arise.

Students can, generally, only transition from the first-year introductory program to the main program if they have an apprenticeship contract with a firm. This makes the transition from the first to the second year of enrollment important for at least two reasons.[9] First, the majority of the up to 47 percent dropout among VET entrants from lower secondary education takes place at the end of the first year introductory program when students must match firms (Groes, Madsen, and Sandoy 2021). This points to the apprenticeship search as a primary barrier for entering VET. Secondly, the student-firm matching market is very similar to the labor market for many graduates in more school-based programs. This implies that our findings may reflect general effects in other dual VET systems (e.g., Austria, Germany, Norway, and Switzerland) and potentially in other more school-based VET systems (e.g., the Netherlands, France, and Sweden).

[9] VET students can also enter school-based apprenticeships if they cannot find an apprenticeship at a firm or have an initial apprenticeship contract lasting less than their full program length. However, they are then required to take any apprenticeship offered, regardless of the offer's location and specialization. As a result, only 7 to 9 percent of all ongoing apprenticeships were school-based between 2017 and 2019 (see appendix table (OA) II.1 from Ministry of Children and Education 2020b).

2.2 The 2015 VET Reform

In August 2014, the Danish government announced a VET reform to take effect in 2015 that instituted a new GPA requirement for entry into VET programs, where, previously, all applicants would be admitted if the program had sufficient slots. The purpose of the reform was to reduce the high VET dropout, make lower secondary students choose VET, increase the general education level within the programs, and increase student well-being in the VET schools (Regeringen 2014, pp. 3-4).[10]

The GPA requirement meant applicants had to pass lower secondary education final exams in both Danish and Mathematics to be accepted directly into VET programs. Students who had not passed either subject would be offered additional tests in the subject(s) at the VET institution and admission if they passed.[11] More than 15 percent of students entering VET before 2014 did not pass either Mathematics or Danish, and the government expected that by reducing the share of below-passing students, they could increase the overall quality in the VET programs and thereby reduce the dropout rate.

The final exam GPAs used for screening students are weighted averages of exam scores from tests taken in May and June at the end of 9th and 10th-grade. The Ministry of Ed-

[10]The reform also contained other components, including increased support for career counseling within programs, consolidating introductory pathways/programs from 12 to 4, creating more pathways to tertiary education for VET graduates, the introduction of 45 minutes daily mandatory exercise, requirements of 25 hours of teaching in the first year of the VET program in 2015 and 26 hours in 2016, and providing more information about the national VET students competition "DM I Skills" (the Danish championship in vocational skills, part of the international Skills competition) to VET students. The reform also introduced a new lower secondary 10th-grade type with integrated vocational classes. These other components, however, are not likely to relate directly to the variation in the share of VET students who did not pass lower secondary education Danish or Mathematics at the VET schools, our emphasis in the empirical analysis, and we, therefore, do not focus on them in this paper.

[11]One program, Social Care, allowed for an exception. Students applying to this program who passed neither their final tests nor their extra tests could nevertheless enter and qualify for remaining in the program by taking supporting coursework.

ucation develops these tests, and test scores are determined through joint deliberation by the student's teacher and an external examiner assigned to score the class exams. This process limits the scope for teachers to manipulate each student's grades. 9th graders take four tests in Danish (spelling, reading, verbal presentation and analysis, and writing), and two in Mathematics (problem solving with and without aid). 10th graders take two Danish exams and one Mathematics exam. The Danish education system uses a 7-point grading scale. Students need a minimum GPA of 02 to pass a subject. [12] Beyond the VET requirement, the final test scores did not affect students. The students are also given preliminary test scores in each subject by their teacher halfway through the school year, which are attached to each student's upper secondary enrollment application. Students apply to pursue 10th grade, general upper secondary, or VET education by March 1st, after receiving their preliminary test scores, but before receiving final test scores. There were no changes in incentives to perform well preliminary tests before and after the reform. We use this fact in the analysis as a robustness check, where we substitute final test scores with predicted final test scores given preliminary test scores without substantive changes to our results.

The reform was successful in reducing the share of students who did not pass either Danish or Mathematics final courses in lower secondary education.[13] Among entering cohorts 2009-2014, slightly less than 20 percent of entering students had not passed either Danish or Mathematics in their lower secondary final exams. However, some institutions

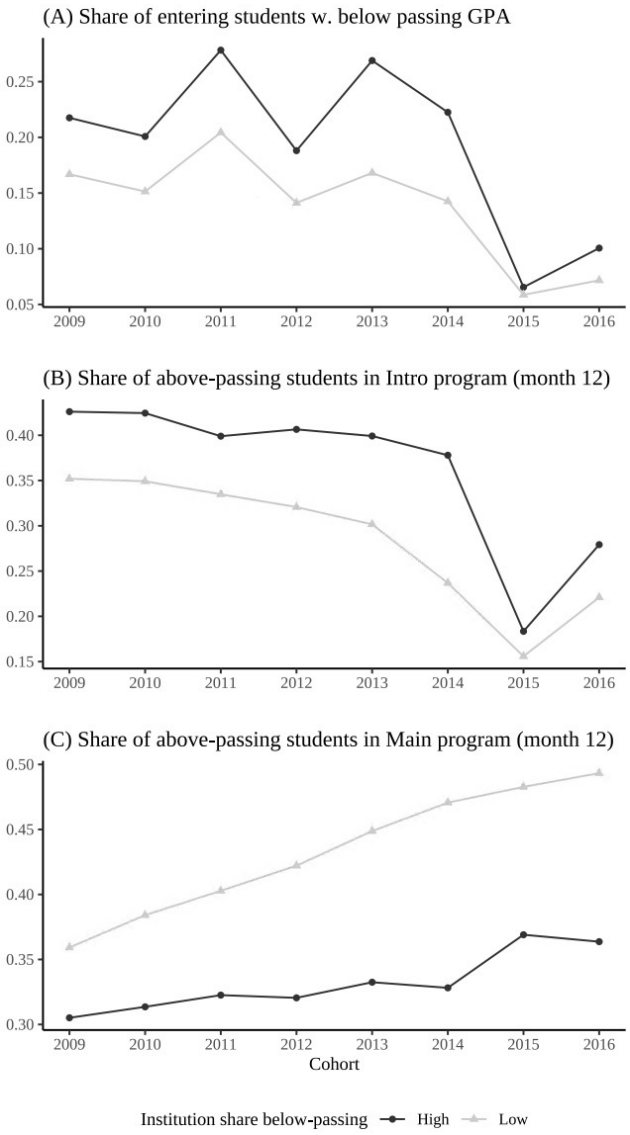
[12] Appendix (OA) II.5 describes the grading system in more detail and includes a conversion to the European ECTS letter grading scheme. Below passing grades are -03 and 00, and passing grades are 02, 4, 7, 10, and 12.

[13] Newspaper coverage from the summer of 2015 suggests that while the agreement was struck in 2014 and affected students applying for VET entry in 2015, many lower secondary education students were surprised by the requirement when they did not pass their Danish or Mathematics courses (Rysgaard 2015). The media coverage suggested that few eligible students showed up to take the supplementary tests that could give them access.

had higher shares of below-passing students before the reform. We illustrate this in Figure 1 panel (A), which is based on administrative data described in section 3, showing the share of below-passing students at ”High” and ”Low” institutions. An institution is classified as ”High” if it had an above-median share of below-passing students (around 0.19) in its 2013-2014 cohort and ”Low” otherwise. We use this classification in the subsequent analysis. Before the reform, ”High” institutions had around 23 percent below-passing students. In comparison, ”Low” institutions had around 15 percent. The institution types appear to be on nearly similar trends in shares of below-passing students before the reform. After the reform, the share of students below-passing declined to around 8 percent for both institution types. This illustrates that the reform effect on shares of below-passing students was stronger at ”High” institutions than at ”Low” institutions. We use this characteristic in our instrumental variables specifications, where we implicitly compare outcomes at ”High” and ”Low” institutions after controlling for institution and year indicators and institution-specific trends.

Panels (B) and (C) in figure 1 show the share of above-passing students entering from lower secondary education that are enrolled in an Introductory program or Main program 12 months after initial enrollment in Vocational education. We focus on above-passing students, as they were unaffected by the reform screening. The figure illustrates that at ”High” institutions, the share of students re-enrolling in another program dropped the most, from around 40 percent to 18 percent. At ”Low” institutions, the share dropped from around 30 percent to around 15 percent in the 2015 cohort. The shares increase slightly the following year. Simultaneously, the share of students entering the Main program rose slightly to ”High” programs after the reform, while it remained on an upward trend with

Figure 1: Share of below-passing GPA VET entrants at VET institutions



Note: The figure is based on administrative data described in section 3. Dark-shaded lines indicate averages over students at institutions with above-median shares of below-passing students entering from lower-secondary education in 2013-2014. Ligher-shaded lines are similar averages at below-median share institutions.

no breaks at "Low" institutions. These figures foreshadow our main findings.

3 Data

The analysis of peer effects in the Danish VET programs is based on administrative data collected from Statistics Denmark and the Danish Ministry of Children and Education. These data can be linked at the individual level.[14]

We use test scores from the final exams in lower secondary education to determine which students are below-passing in the analyses. The test score data comes from Statistics Denmark and contains subject-specific preliminary and final exam test scores for all students in the Danish education system from 2001 to 2017. It also shows whether the student was absent from all or some of the subject exams. Using this data, we calculate the average test scores for Danish and Mathematics for all students sitting for the final exams according to the weighting scheme used to determine access to VET after 2015 (Ministry of Children and Education 2020a).[15]. We calculate the same GPA using the preliminary test scores recorded for each subject to address concerns that students could potentially manipulate their final exams. For both sets of GPAs, we determine the minimum GPA of the two and create an indicator variable, taking the value one if the student did not pass either subject and zero otherwise. We then use the indicator variable to calculate the share of below-passing applicants to each VET institution.

[14] Appendix (OA) IV provides an in-depth description of the data preparation process.

[15] Nearly all lower secondary education students sit the mandatory tests in Danish and Mathematics. Only .5 percent of students do not take final tests simultaneously with other students. This may be because the student was sick during the exam or for different reasons. While some students take their exams later in the summer, we exclude this small set of students from the test score datasets as these test scores may have arrived too late to have been meaningful for determining entry into VET.

We use data from the Danish Ministry of Education on lower secondary 9th and 10th-grade students' applications to education to construct our instrumental variable and define the sample of VET entrants. The data includes the number of ranked education program choices each student submits through the website "www.optagelse.dk", run by the Ministry of Education. The data also contains information on when the student submits the application, what school they attend, and which institution they apply to. The data is available for all students who apply to enter the optional 10th grade or any upper secondary education from the 2009 graduating cohort until the 2016 cohort.

We also draw on administrative data from Statistics Denmark to determine when a student is enrolled in lower secondary education and whether the student is enrolled in an introductory or main VET program one year after initial enrollment. The KOTRE registry contains information on education participation spells from 1973 through the end of 2017 for all formal education pursued in Denmark. The registry also contains information on the start and end date of the spell and the type of program pursued, including VET introductory or main programs. We use this data to construct our main outcome variables for the analysis: indicators for whether the student is enrolled in a main VET or introductory VET program 12 months after starting their VET program.[16]

We collect demographic information on students and their families from administrative registers from Statistics Denmark, including age on January 1st in the application year, gender, immigrant status (Danish, first, or second-generation immigrant), and home municipality in January. We observe the demographic information for all students appearing

[16] We also use it to identify those students who initially enroll in VET that become our core sample and for the supplementary analysis in Appendix (OA) V where we investigate the subsequent education transitions of those students who initially enroll in VET and drop out after the first year.

in the test scores and application registers for cohorts 2009 through 2015, and 99 percent of all VET applicants are from the 2016 cohort.[17] The same register also contains family linkages, allowing us to observe each student's parents and their demographic information. We additionally use data from an education registry to obtain parents' highest attained education and construct variables indicating whether at least one parent has a tertiary degree.

Finally, we obtain information on parents' total income from tax registry data. Total yearly income includes salaries, own-business and capital income, and public transfers, which we deflate to 2015 values using the Danish CPI. The parental income variables included in the analysis are the parents' five-year average income leading to student enrollment in VET. In supplementary analyses, we also use the registry data on age, education attainment, and total deflated income to construct average total income profiles for all working-age individuals with a VET and lower secondary education as the highest education level between 2000 and 2015.

3.1 Sample and Descriptive Statistics

The analyses focus on VET entrants from lower secondary education. Therefore, we construct a sample of students who apply to and enter VET, having graduated from either 9th or 10th grade lower secondary education in the same year. The sample only includes students with final test scores from Danish and Mathematics, as we need these to determine if the students are in the above- or below-passing group. In the analyses, we only estimate the effects on students with a passing minimum GPA in Danish and Mathematics.

Table 1 shows means and standard deviations for a set of variables showing the stu-

[17] Table (OA) IV.1 shows the coverage of demographic data across cohorts of students.

Table 1: Summary statistics for students entering VET, 2009-2016

	Above-passing (N=73,232)		Below-passing (N=14,304)		Diff. in	
	Mean	SD	Mean	SD	Means	P-value
Entry from 10th grade (vs. 9th)	0.591	0.492	0.599	0.490	0.008	0.085
Age at entry	15.869	0.691	16.018	0.764	0.149	<0.001
Female	0.333	0.471	0.374	0.484	0.041	<0.001
Immigrant (1., 2. gen)	0.025	0.156	0.073	0.261	0.048	<0.001
GPA - Mathematics	5.183	2.515	1.103	1.857	-4.080	<0.001
GPA - Danish	5.029	2.095	2.645	1.981	-2.384	<0.001
Min. subject GPA	4.069	1.833	0.407	0.716	-3.663	<0.001
Min. prelim. subject GPA	4.037	1.898	1.981	1.337	-2.056	<0.001
Mother's age	44.298	4.780	43.867	5.087	-0.430	<0.001
Mother's income (1,000 DKK)	324.352	125.946	300.763	113.476	-23.589	<0.001
Mother's ed. = lower sec.	0.252	0.434	0.363	0.481	0.111	<0.001
Mother's ed. = VET	0.513	0.500	0.454	0.498	-0.058	<0.001
Mother's ed. = tertiary	0.171	0.377	0.121	0.326	-0.050	<0.001
Father's age	46.961	5.571	46.827	5.968	-0.133	0.018
Father's income (1,000 DKK)	387.390	289.138	344.570	251.378	-42.820	<0.001
Father's ed. = lower sec.	0.285	0.452	0.389	0.488	0.104	<0.001
Father's ed. = VET	0.562	0.496	0.479	0.500	-0.082	<0.001
Father's ed. = tertiary	0.101	0.301	0.076	0.264	-0.025	<0.001
Parent's ed. = lower sec.	0.252	0.434	0.363	0.481	0.111	<0.001
Parent's ed. = tertiary	0.254	0.435	0.195	0.396	-0.059	<0.001
Parents' income (1,000 DKK)	694.512	334.139	620.237	299.837	-74.275	<0.001
Institution average min. GPA	3.481	0.528	3.223	0.548	-0.258	<0.001
Institution share below-passing	0.160	0.078	0.203	0.087	0.043	<0.001

Note: The table shows summary statistics for the main sample, students who apply to and enter VET from lower secondary education between 2009 and 2016. Parental income is deflated to 2015 DKK values, and average over five years prior to student's VET entry. The average DKK/USD exchange rate was 6.72 in 2015. Institution variables show averages taken across students in the sample.

dents' demographic background, GPA from final tests, parental background, and average GPA and share of below-passing students at the institution the student enters. The final two columns show the difference in means and p-values under a null hypothesis of no difference between above-passing and below-passing students. Nearly all group differences are

statistically significant at a 5 percent significance level. Slightly less than half of students entering VET come from 10th grade, and the average age of the entrants is 15.9 among passing students and 16 among below-passing students. The below-passing students are slightly more likely to be female (4.1 percentage points) and substantially more likely to be first or second-generation immigrants (12.4 percentage points). While above-passing students have nearly similar GPAs, around 5 in Danish and Mathematics from lower secondary school final exams, below-passing students struggle substantially more in Mathematics than in Danish, where their GPA is 4 points lower than above-passing students and .9 points below the passing grade of 2 at 1.1. Their GPA in Danish is just above passing at 2.6. The average below-passing students are also likelier to come from homes with a parent whose highest education is lower secondary. That is nearly ten percentage points more than among above-passing students. Above-passing students' parents are more likely to have VET or tertiary degrees in general and have parental incomes on average 74,290 DKK (11,050 USD) higher than the below-passing students. These differences all point to below-passing students from less advantaged backgrounds than above. This implies that reducing the share of below-passing students in VET institutions would change the contextual characteristics of entering students.

4 Empirical Strategy

To investigate the effect of the below-passing students on above-passing students' likelihood of entering the main program and not dropping out of VET, we model above-passing students' participation in main and introductory program VET as a linear function of the share of below-passing students entering the VET institution from lower secondary educa-

tion, $belowshare_{sc}$,

$$y_{ist} = \lambda belowshare_{sc} + \delta X_{isc} + \sum_{c} \alpha_c C_c + \sum_{s} \alpha_s S_s + \sum_{s} \gamma_s S_s T + \epsilon_{isc}. \qquad (1)$$

The left-hand side variable, y_{ist}, is an indicator for participating in a VET Introductory or Main program 12 months after initial entry into VET programs, X_{isc} is a set of individual-specific control variables, and ϵ_{isc} is an individual specific error-term. The student level is indicated by subscript i, the institution the student attends by subscript s, and the student's cohort by subscript c.

Because students' grades are determined before entering VET, the regression model focuses on what Manski (1993) termed contextual effects. The model can be viewed as a reduced form that subsumes a traditional linear-in-means model of peer effects (e.g., Blume et al. 2015) that attempts to disentangle contextual effects from other within-class and -interaction determinants of outcomes (Blume et al. 2015). Our data do not include information from the individual VET institutions (e.g., teacher assignments, class memberships, or student study groups) that might otherwise help disentangle the mechanisms through which the reduced form estimates might operate.

We take several steps to ensure that the estimates of the coefficient λ do indeed identify the composite peer effects of below-passing students within institutions. To account for potential self-selection of below-passing students into institutions where other students are more or less likely to find apprenticeships due, e.g., to local labor market conditions, we control for school specific indicators S_s. We include cohort indicators C_c to account for general but year-specific shocks to the apprenticeship labor market, such as economic upswings that can make firms more willing to hire apprentices as the market for skilled

labor tightens (Muehlemann, Pfeifer, and Wittek 2020). This implies that we estimate peer effects from within the institution across time variation in peer shares, an identification strategy introduced by Hoxby (2000) in the peer effects literature.[18] Importantly, institutions may attract different types of students over time, implying that student body compositions change. This can happen, for example, if local industrial composition changes, inducing fewer students to take particular (VET) educations (Acton 2021). We also include institution-specific linear time trends, S_sT, in the specifications. Table (OA) I.5 shows that our findings are robust to adding second-order polynomial institution time-trend controls.

Secondly, if we were to include all VET entrants from lower secondary education in the estimation sample, this could lead to a mechanical link between the peer-share and the outcome, as below-passing students typically have higher likelihoods of dropping out of VET entirely (Stratton et al. 2018). Therefore, we only include students with above passing GPAs in Danish and Mathematics when we estimate the model. Splitting the affected sample from the affecting sample in this way is common in previous studies of disruptive peers (e.g., Imberman, Kugler, and Sacerdote 2012; Gould, Lavy, and Paserman 2009).

Thirdly, we use the shock to institution shares of below-passing students that resulted from the 2015 VET reform as an instrument for the actual shares. Figure 1 showed that institutions with high shares of below-passing applicants before 2015 experienced larger declines in shares of below-passing students after the reform. We use this information to create a binary instrument, $treat_{sc}$, that takes the value one in post-reform years if the institution the student enters has an above-median share of below-passing students entering

[18] The approach has been used, e.g., to study the effects of having more peers who experienced domestic violence (Carrell and Hoekstra 2010; Carrell, Hoekstra, and Kuka 2018), and a higher share of female or elite SES peers (Brenøe and Zölitz 2020; Cattan, Salvanes, and Tominey 2022).

from lower secondary education across 2013 and 2014. The median 2013-2014 average institution share of below-passing students is near 19 percent (see Table (OA) VI.1). The instrument takes the value zero otherwise. We subsequently refer to above-median institutions as high-share institutions and institutions with below-median shares as low-share institutions. We use average pre-reform institution applicant shares to define the instrument, rather than same-year applicant shares, as it is possible that students who expect not to be able to pass Danish or Mathematics in final exams or the optional VET school tests might not apply after the reform. The first stage regression is

$$belowshare_{sc} = \pi treat_{sc} + \lambda X_{isc} + \sum_{c} \theta_c C_c + \sum_{s} \theta_s S_s + \sum_{s} \gamma_s S_s T + \varepsilon_{isc}. \quad (2)$$

The first stage includes the same controls as the main model. This implies that the instrument compares within-institution changes across high-share and low-share institutions before and after the reform.

The instrumental variable identification requires that the instrument be independent of other confounders conditional on institution and cohort fixed effects and that the instrument predicts the changes in within-institution shares of below-passing students. We show robust F-statistics for leaving out the instrument in the first-stage regression to test the second relevance condition. As figure 1 suggests, the reform instrument has strong predictive power over standardized shares of below-passing peers. The associated F-statistics are typically above 4,000 across specifications, well above the traditionally used threshold of 10 (Stock and Yogo 2005) and above more recently suggested thresholds around 140 (Lee et al. 2020). This implies that traditional t-statistics-based confidence intervals should have the correct coverage if the exclusion restriction holds.

While it is not possible to directly test the exclusion restriction, we perform several checks that would indicate potential violations without finding signs of it. First, if the instrument is conditionally independent, then adding additional individual-level controls that predict dropout behavior among VET students to the regression should have little effect on the estimated IV coefficient (Oster 2019). We therefore first estimate the model without individual level controls and then sequentially add variables that Groes, Madsen, and Sandoy (2021) and Stratton et al. (2018) show strongly predict dropout behavior among VET entrants, including the students own minimum GPA in lower secondary school final tests in Danish and Mathematics, an indicator for whether the student is female, an indicator for whether at least one parent has a tertiary degree, and fixed effects for the field of study the student enters. We show in table (OA) I.5 that adding these individual controls does not substantively alter the estimated coefficients.

Secondly, because the instrument should not be able to predict outcomes or below-passing shares before the reform beyond what can be expected under random assignment, we conduct a placebo test, where we drop post-reform cohorts and let the instrumental value take the instrument share in either of the years 2009-2014. (OA) VII.1 shows placebo first stage and reduced form instrument coefficients, as well as robust first stage F-statistic for leaving out the instrument in the first-stage regression. The placebo-assigned instruments cannot predict outcomes in the pre-reform period. This provides suggestive evidence that the instrument exclusion restriction is plausibly satisfied.

The instrument specification compares post-reform high-share institutions with pre-reform high-share institutions and low-share institutions within institutions across time. However, this binary instrument does not account for all institutions with below-passing

students experiencing declines in below-passing student shares. This is important if there are non-linearities in the effects of the share of below-passing peers. We first test how sensitive our findings are to the instrument specification by defining a continuous version of the instrument. It takes the value zero before the reform and the 2013-2014 institution average share of below-passing applications after the reform for the institution the student entered. Intuitively, this instrument captures the heterogeneity in the expected reform effect. We replicate all our main binary instrument findings using the continuous instrument in the Online Appendix. The continuous instrument estimates follow the same pattern as the binary instrument but are slightly attenuated. This supports the interpretation that the peer effects may be heterogeneous across peer shares. Second, we create a set of saturated instrumental variables that are indicators for each institution that interacted with a post-reform indicator (see Table (OA) I.8). The saturated IV will pick up changes in peer shares due to the reform within each institution, using pre-reform to post-reform changes in shares to predict enrollment behavior. The estimates from this specification are similar to the continuous instrument estimates.

We also address the concern that our dataset contains a few large institutions with more than 250 entering students and some small institutions with less than ten students, which could both be driving our results. Figure (OA) I.1 illustrates the right-skewed size distribution by averaging the number of entering students from lower secondary education between 2009-2014. The larger institutions may dominate results due to their high share of students in the dataset. In comparison, the smaller institutions can see extreme fluctuations in peer shares across time, creating institution-level outliers. We, therefore, re-estimate the main models with various specifications that either control flexibly for institution size or drop

institutions with fewer than ten students and the largest five institutions in table 5. The findings are generally robust to these changes, though the Main program effects appear stronger at some larger institutions. We discuss this further in section 5.4 when we turn to supply and demand-based explanations for our findings.

Students may also become more likely to select certain institutions over time, thereby changing the composition of above-passing students in ways that correlate with the share of below-passing peers, which could bias our estimates either up or down. We, therefore, calculate the average background characteristics for the above-passing students entering each institution cohort and add these to the model. The estimates can be seen in table (OA) I.5, which demonstrates that including these cohort controls does not challenge the main findings. However, part of the introductory program re-enrollment effects may be related to the composition of above-passing students.

Another concern is that when the number of students decreases at high-share institutions because of the 2015 reform, the funding per student also increases at these institutions. However, this is unlikely to drive our results. The central government funds VET schools and receives 92 percent of their function based directly on the number of active students. Of the remaining funding, 5 percent is project-based funds that schools can apply for, e.g., to upgrade equipment used in teaching, and the remaining part goes to relatively fixed infrastructure costs, including buildings. Because most of the funding is student-contingent, funding per student is unlikely to drive our findings. In particular, it is hard to find good reasons why *increasing* shares of below-passing students, and thereby reducing funding per student, should make students *more* likely to re-enroll in other programs, as we show in the next section, even after controlling for student cohort sizes.

Finally, students may be induced to attempt to manipulate their grades after the introduction of the reform, thereby changing the composition of students that enter our estimation sample.[19] If such manipulation occurred, it could bias our results. To address this concern, we first note that students had no incentive to attempt to manipulate their preliminary test scores, as these did not affect whether students were allowed to enter their VET program. We, therefore, re-estimate our findings, focusing instead on the sample of students whose predicted final GPA given their preliminary GPA is above passing[20], and we also recalculate the share of below-passing students using preliminary scores instead of final scores in Table (OA) VI.1. The results remain similar across these changes in specifications, though the estimates predictably grow larger under specifications with weaker first stages. The most influential robustness check is to change how the below-passing peer share is measured using preliminary instead of final test scores. We believe these differences likely reflect the first stage becoming less predictive of actual shares, thereby inflating the estimates into less precise specifications.

5 The effect of below-passing peers on above-passing students

We first present the main results, focusing on how the standardized share of below-passing peers affects whether above-passing students enter the Main program or another VET Introductory (Intro) program 12 months after starting VET. Enrolling in the main program

[19] News media interviewed VET institutions in 2015, finding that applicants generally were unaware of the newly instated GPA requirements (Rysgaard 2015). This suggests that grade manipulation may not be a substantive problem.

[20] We create the predicted final scores for all students using a model constructed from regressing final minimum GPAs on a fourth order polynomial in preliminary minimum GPA in pre-reform years, thereby avoiding to include manipulative behavior in the model construction.

implies that the student has moved forward in their program. They can do this if they have found an apprentice within a firm or are temporarily enrolled in a school-based apprenticeship, expecting to find an apprenticeship position. If students enter another Intro program, they have dropped out of their initial program but have not left the VET education system.

The first panel of table 2 contains the IV estimates using a binary instrument. The IV point estimate for the Intro program outcome is .09, with a standard error of 0.012, while the estimate for Main program enrollment is -0.032 (.013 SE). The estimates suggest that as the share of below-passing students increases by one standard deviation, above-passing students become three percentage points less likely to enroll in the main program but nine percentage points more likely to enroll in another VET program. The estimates implicitly suggest that above-passing students become six percentage points less likely to drop out.

Both regressions include fixed effects for entry year and institution and institution continuous-year controls to control for institution-specific application patterns that may change over time. We added controls for the students' standardized GPA, gender, and highest attended lower secondary grade level and entered the VET field for increased precision. Table (OA) I.1 in the appendix shows that the estimated coefficients remain the same as we add individual controls beyond the fixed effects and institution trends necessary for our empirical design. When we add a quartic control for institution trends, the main program estimate declines to -0.21, while the Intro estimate increases to .097. One way to interpret this is that institutions attract slightly different students over time. Still, these compositional changes are sufficiently small that they do not change the substantive peer effect findings.

One possible concern with the IV estimates is that the reform does not substantially af-

fect the share of below-passing students across high and low-share institutions. The table 2 third panel shows the first-stage coefficient estimate from regressing the standardized share of below-passing students on the reform indicator with the full set of controls. The estimate at -0.939 (SE 0.013) shows that the high-share institutions experienced a nearly one standard deviation greater decline in the share of below-passing students. The heteroskedasticity robust F-statistic for leaving out the instrument in the first stage regression is 4,959. This supports the interpretation that the reform substantially affected the share of below-passing students across institution types.[21]

Our identifying variation comes from the reform that reduced the share of below-passing students. The second panel in table 2 shows the reduced form effect of the instrument on the two outcomes. High-share institutions became 8.5 percentage points less likely to enroll in another Intro program after the reform and three percentage points more likely to enroll in the main program. On the one hand, the reform appears to have gotten more above-passing students into the Main program, as intended, but it may simultaneously have reduced the share of the above-passing students and pushed more students out.

5.1 Contextualizing the estimated peer effects

Peer effects studies vary in empirical specification, making direct comparisons difficult. However, Cattan, Salvanes, and Tominey 2022, table 2 use an estimation setup that is broadly similar to ours to study the effects in Norwegian high schools of standardized shares of peers with elite-educated parents on students' likelihood of entering elite edu-

[21] We find a similarly strong first stage (F-statistic = 5,247.68) when we let the instrument take on continuous values corresponding to expected shares of screened-out students after the reform in appendix table (OA) I.2.

cation. Their estimated effects for low-SES and high-SES from having peers with elite-educated parents are comparable in size to our VET peer effects estimates. One interpretation of this comparability is that students who differ substantially from their peers generally can have sizable effects on important student-level outcomes.

To further put our findings in context, we compare them to findings from papers studying the effects of potentially adverse students in academically oriented learning environments. Imberman, Kugler, and Sacerdote (2012) find that having more natural-disaster refugee peers in class has an average near-zero effect on local students. However, students in classes receiving lower GPA refugees tend to have worse test scores than students whose classes received higher GPA peers. Lavy, Paserman, and Schlosser (2012) show that having grade-repeaters in Israeli schools negatively affects the likelihood that non-repeaters pass their final exams. Bifulco, Fletcher, and Ross (2011) also use a within-school-across-time design and find null effects of having higher shares of low-GPA minority peers on the likelihood of attaining a post-secondary degree. Finally, Carrell and Hoekstra (2010) and Carrell, Hoekstra, and Kuka (2018) show that students in Florida primary schools have no impact on test scores from having peers who grow up in homes that are later reported for domestic violence, but do report worsened class social environments. They also tend to have lower earnings when entering the labor market. These studies suggest limited adverse learning impacts from having lower-achieving and potentially challenged peers, with effects possibly arising at the time of labor market entry. Our findings complement these studies, showing that VET students may have worsened labor-market outcomes since Main program enrollment implies that students have or are expected to match with firms for apprenticeship positions. Our finding that fewer students drop out of the VET programs

entirely and includes some attempts to re-enter contrasts with the negative findings from previous studies. However, the pattern of our findings is consistent with the possibility of "small fish" effects where above-passing students may use reference points among below-passing students to decide whether to drop out entirely if they cannot find apprenticeships.

5.2 Outside options

We next study what students do if they are not in VET 12 months after enrollment when below-passing peer shares change. We show in appendix (OA) V that the typical 2008-2014 VET dropout does not enroll in any education within the next five years. However, the students affected by changing shares of below-passing students may differ from the typical VET dropout. To study the effects on outside option choices, we substitute our Main and Introductory program outcomes with binary indicators for enrolling in 10th grade, general upper secondary education, or having left the formal education system 12 months after initially enrolling in VET. We include 10th-grade enrollment partly as a check. Students should not be able to enroll in 10th-grade education one year after enrolling in VET; therefore, we should not be able to find any effects on 10th-grade enrollment.

The first panel in table 3 shows the estimated coefficients on the standardized share of below-passing students entering from lower secondary education for each outcome.[22] The second panel shows the corresponding reduced-form estimate. Reassuringly, the second column shows a precisely estimated zero coefficient on enrollment in 10th-grade education from having one standard deviation more below-passing peers. The first column shows a statistically insignificant coefficient of -0.009 for entering high school. The final column

[22] Table (OA) I.6 shows the same regressions using the continuous instrument. Again, we find slightly attenuated but similar effects as in the main models.

shows a negative 3.5 percentage points estimate (SE 0.012) for leaving the formal education system entirely. This suggests that students affected by their below-passing peers are unlikely to ”drop up” to general upper-secondary education. Rather, they are on the margin of leaving the education system entirely.

5.3 Heterogeneity by students' own GPA

The linear-in-share model we estimate in the previous sections contains the implicit assumption that the effect of the below-passing GPA peers is similar across the distribution of skills for the higher GPA students. However, the effects of below-passing peers may vary by students' previous academic performance, implying non-linear relations (Sacerdote 2014). Imberman, Kugler, and Sacerdote (2012), for example, shows the inflow of high-GPA students to Houston high schools, caused by evacuations from areas struck by Hurricane Katrina and Rita, increased local high-GPA students' academic performance. We, therefore, follow the approach of Imberman, Kugler, and Sacerdote (2012) and estimate the main model separately by quartiles of the passing students' minimum GPA. Appendix Figure (OA) I.2 shows the cumulative density of students by minimum GPA, and in particular, that some students can be assigned to either one of two quartiles because the distribution of GPAs is discrete. We randomly assign students on the margin to either of the quartiles.

The panels in table 4 show the IV estimate for the peer effects by sample GPA quartile. The estimated effects are generally stronger for individuals with lower GPAs. The first quartile Introductory program coefficients are 0.121 and 0.128, while the Main program estimates are -0.052 and 0.042. The estimated coefficients decrease in size for the Intro-

ductory program effect until the fourth quartile sample is estimated at 0.043. In contrast, the Main program effect is weakest for the third quartile at -0.007 and then increases to -0.042 for the top GPA quartile. First, this illustrates that peer effects may be stronger for the GPA-wise more similar low-GPA students. Secondly, these estimates also indicate that our findings are not driven by would-be-below-passing students anticipating the reform effect and thereby making additional efforts to pass their final exams in lower secondary education so that these students wrongly enter our estimation samples. However, such students are unlikely to be able to increase their grades enough to move beyond the first and possibly second GPA quartile, affecting only estimates at the lower end of the GPA distribution. The fact that we observe non-zero coefficients, particularly for the Introductory program, throughout the GPA distribution suggests that manipulation is not a perfect explanation for our findings.

5.4 Supply and Demand Explanations

One may be concerned that our results are driven by decreased competition for limited apprenticeship positions among firms. To fix ideas, assume that firms' demand for apprentices is inelastic in the short term and that below- and above-passing students are substitutes from firms' perspective. Then, decreasing the share of below-passing students will create less competition for positions, making firms more likely to hire a given above-passing GPA apprentices. A one standard deviation increase in the within-institution over-time share of below-passing peers is 3.6 percent (see appendix table (OA) I.3). This matches the estimated coefficient on main program enrollment, a decrease of 3 percentage points.

To understand the explanatory power of effects from changes in the potential supply

of apprentices, we re-estimated the main models, adding various controls for the size of the entering student population from lower secondary education. If below- and above-passing students are perfect substitutes, and apprentice demand is perfectly inelastic in the short term, we should see that controlling for cohort size reduces the coefficients to near zero. The resulting estimates are in table (OA) I.7, where the first column contains the original Main and Intro program estimates. In the second column, we add a second-order polynomial in the number of students entering the institution from lower secondary education.[23] This reduces the estimated coefficient for main program enrollment from -0.032 to -0.028 (SE .013 and .014). The intro program coefficient declines from .09 to .08 (SE .012 and .013).[24] This suggests that competition is at least part of the explanation for our findings. Additionally, it suggests that below- and above-passing students are, possibly imperfect, substitutes from a firm perspective. However, supply changes do not appear to explain the sizeable re-enrollment estimate.

If competition in the labor market depends on the size of the matching market, then the effect of competition is likely more pronounced in larger institutions. In the subsequent columns, we drop the smallest five institutions, the largest five institutions, and finally, all institutions with less than ten entering students. Dropping the largest institutions reduces the Main program estimate to -0.016 and the Intro program estimate to .062. Dropping the smallest institutions does not change the estimates, illustrating that small outlier institutions do not drive our findings. While we find some support for the explanation that our

[23] VET institutions can also receive students that do not come directly from lower secondary education. Appendix table (OA) I.7 shows similar results as controlling for the number of entering students from lower secondary education.

[24] Appendix table (OA) I.4 shows that adding the size control in the 2SLS estimations with the continuous instrument introduces a similar pattern, where both Main and Intro program enrollment is reduced, but there remains a substantive Intro program estimate.

estimates are driven by changing the supply of students, there remains a strong effect on Intro program participation.

6 Discussion

We investigated whether having a higher share of below-passing GPA students in workforce-oriented upper secondary programs (VET) affects above-passing GPA students' likelihood of staying enrolled in VET programs and entering Main programs that require apprenticeship positions, a core component of dual program VET system education. We study these effects in response to a Danish reform in 2015 implementing a GPA requirement for lower secondary education students who wanted to enter VET. The result of the reform was that the share of below-passing GPA students in VET dropped substantially at previously high-share institutions and dropped less at previously low-share institutions. We use the reform shock to the institution level share of peers to overcome typical challenges in identifying peer effects due to lack of external variation in peer shares (Sacerdote 2014) in a context typically associated with self-selection.

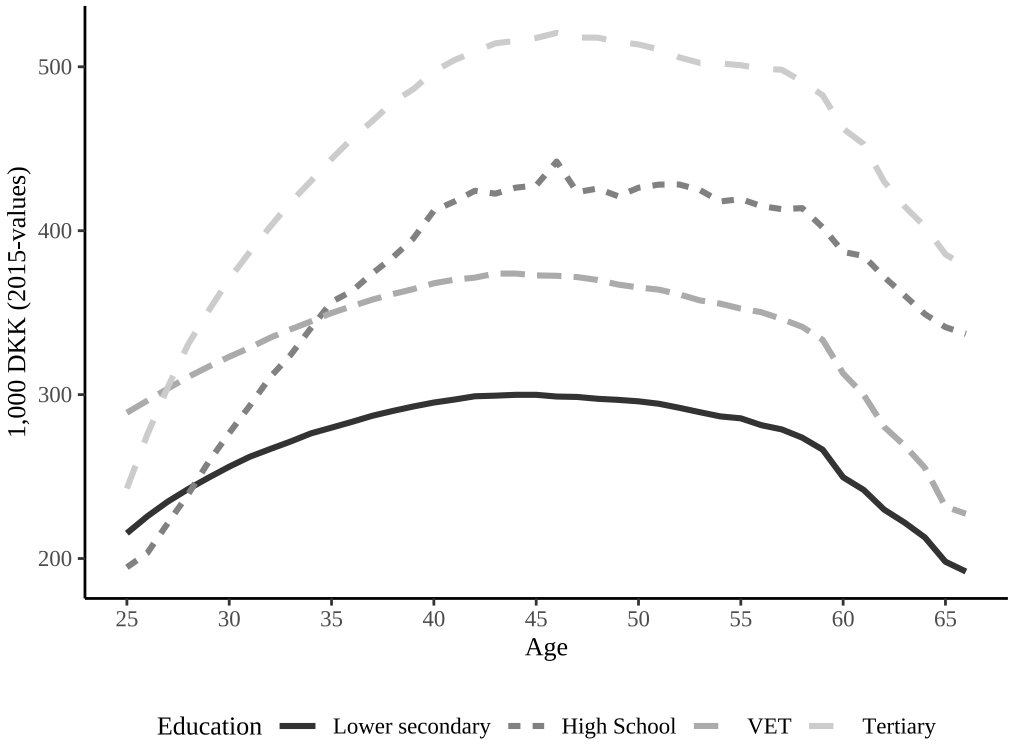
The results suggest that having more below-passing GPA peers positively affects the above-passing GPA students enrolling in VET one year after initial enrollment. This transition point is important in the Danish VET setting, as students typically participate in Introductory school-based learning within the first school year and then move on to Main programs with apprenticeship learning starting in the second year. However, we find a small negative effect on the likelihood of entering a Main program and, thereby, apprenticeships, which may partly be explained by increased competition from below-passing students. On the other hand, we find that above-passing students become substantially

more likely to re-enroll in other VET Introductory programs. We show in supplementary analyses that the marginal students would likely have dropped out of the education system entirely had they not been induced by below-passing peers to remain in the VET system.

Our data does not allow us to investigate the long-run peer effects. However, as is the case internationally, obtaining upper secondary degrees in Denmark is associated with substantial earnings premiums compared to having no education qualifications beyond lower secondary education. We illustrate this point in Figure 2, showing the average total income by highest attained education level and age for all individuals aged 25-65 appearing in the Danish income registers.VET graduates have around 30 percent higher incomes than those with lower secondary education. If marginal school leavers end up without degrees beyond lower secondary education, the descriptive difference between income groups suggests a substantial income loss over a lifetime. The figure also shows a substantive premium for general upper secondary and tertiary degrees over VET. This could suggest that students on the margin between VET and general upper secondary education may fare better with fewer below-passing peers. However, Brunner, Dougherty, and Ross (2023) and Silliman and Virtanen (2022) cast doubt on this interpretation, as they show that students on the margin between comprehensive career and technical and vocational education in the U.S. and Finland tend to have better completion, employment, and earnings outcomes if they enter the vocational education. In this perspective, our findings suggest that reducing the share of academically challenged students from the applied VET programs is not beneficial for the marginal student, neither in the short- or long-run. A broader set of evidence also suggests that secondary technical education programs may smooth the transition to the workforce (Brunner, Dougherty, and Ross 2023; Kemple and Willner 2008; Ryan 2001;

Silliman and Virtanen 2022), further emphasizing the potential loss of social value when academically low-ability students are screened out of such programs.

Figure 2: Total income by age and highest attained education for the Danish population between 25 and 67



Note: The figure shows the average income by age and highest attained education for all individuals appearing in the Danish tax registers between 2000 and 2015. We include individuals between the ages of 25 and 67 who are not studying toward a degree at the measurement time. Total income includes all tax liable salaries, personal business income, capital income, and social transfers. We deflate yearly incomes to 2015 values using the Danish CPI. The 2015 DKK/USD conversion rate was 6.72.

Our findings also suggest that workforce-oriented education may be less susceptible to 'bad apple' effects like those found in previous studies of disruptive peers in academically-

oriented learning environments (e.g., Carrell, Hoekstra, and Kuka 2018, Imberman, Kugler, and Sacerdote 2012, and Lavy, Paserman, and Schlosser 2012). Instead, it appears that ”big fish in a small pond” effects (Marsh 1987; Elsner and Isphording 2017), where students benefit from having less academically able peers as points of comparison in the workforce-oriented programs, outweigh any negative peer effects. One hypothesis for how these positive peer effects may arise is associated with the structure of the VET program, where students are required to find apprenticeships with firms to enter the main program after the first year of studies. During our study, we contacted several firms, VET students, and VET and industry interest organizations members to investigate how students perceived their academically challenged peers and what firms search for in interest organizations. While we do not claim that the interviews live up to standards for rigorous qualitative research (Small and Calarco 2022), our conversations suggested that among the key factors that firms consider when searching for apprentices are diligence and motivation.Students and previous students, when asked about their relation to academically challenged peerssuggested that while the less-motivated peers may have been uncomfortable or disruptive in class, the contrast bolstered their feelings of preparedness. This matches the theoretical arguments if the apprenticeship market and VET institutions generally function according to these principles. Our study cannot speak to actual peer interactions within the VET institutions and the search behaviors of the students. We regard this as an important area of study for future research.

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Table 2: IV, reduced form, and first stage estimates of below-passing peer share effect on participation in Introductory and Main VET, instrumented by binary reform indicator.

	Intro (month 12)	Main (month 12)
IV		
Share peers below passing (std)	0.090***	-0.032**
	(0.012)	(0.013)
Num.Obs.	72388	72388
Reduced Form		
Binary IV	-0.085***	0.030**
	(0.011)	(0.012)
Num.Obs.	72388	72388
First Stage		
Binary IV	-0.939***	-0.939***
	(0.013)	(0.013)
Num.Obs.	72388	72388
Individual controls	Y	Y
Year FE	Y	Y
Institution FE	Y	Y
Inst. X year (cont.) FE	Y	Y
Grade level FE	Y	Y
VET Field FE	Y	Y
F-stat (1st stage)	4959.29	4959.29
IV variable	Binary	Binary

Note: The table shows 2SLS, First Stage, and Reduced form regression coefficients from regressing indicators for Introductory or Main program participation (12 months after enrollment) onto the instrumented share of peers entering the VET school from lower secondary education who did not pass Danish and/or Mathematics in lower secondary education, and a set of individual controls and fixed effect indicators. The estimation sample consists of VET students entering VET from lower secondary education who have passed their final exams for lower secondary Danish and Mathematics. Students in Main VET have entered the apprenticeship component of the VET program, whereas students in the Intro program have dropped out of their initial program to start another program. The binary instrument takes the value one in years from 2015 if the student enters an institution that had an above-median share of below-passing entering students in 2013-2014 and zero otherwise. The remaining right-hand-side variables include the student's standardized GPA, an indicator for being female, and an indicator for having at least one parent with a tertiary degree. The fixed effect indicators include year, grade level, entered field indicators, and entered institution indicators. They finally include entered institution times continuous year variable interactions. First-stage F-statistics show the heteroskedasticity robust F-statistic for leaving out the instrumental variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent level; ** 5 percent level; * 10 percent level.

Table 3: IV and reduced form estimates of below-passing peer shares on participation in outside options.

	High School	10th Grade	Outside ed.
IV			
Share peers below passing (std)	-0.009	0.001	-0.035**
	(0.008)	(0.002)	(0.012)
Num.Obs.	72470	72470	72470
Reduced Form			
Binary IV	0.008	-0.001	0.033**
	(0.008)	(0.002)	(0.011)
Num.Obs.	72470	72470	72470
Individual controls	Y	Y	Y
Year FE	Y	Y	Y
Institution FE	Y	Y	Y
Inst. X year (cont.) FE	Y	Y	Y
Grade level FE	Y	Y	Y
VET Field FE	Y	Y	Y
F-stat (1st stage)	4965.14	4965.14	4965.14
IV variable	Binary	Binary	Binary

Note: The table shows IV and Reduced Form estimates from regressing indicators for being enrolled in 10th grade, high school, or being outside the education system on the instrumented share of peers entering VET from lower secondary education who have below passing final exam GPAs in Danish or Mathematics. The instrument is a binary variable taking the value one from 2015 onward if the student enrolls at an institution with an above-median share of below-passing entrants from lower secondary education in 2013-2014. It takes the value zero otherwise. Individual controls include the student's minimum GPA in Mathematics or Danish, a female indicator, and an indicator for having at least one parent with tertiary education. The fixed effects include indicators for cohort year, institution, lower secondary education grade level the previous year, and the VET field the student enters. Finally, they include interactions between entered institution indicators and a continuous year variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent; ** 5 percent; * 10 percent.

Table 4: Heterogeneity in peer effects by student GPA quartile using binary instrument

	Intro (month 12)	Main (month 12)
First GPA quartile		
Share peers below passing (std)	0.121***	-0.052**
	(0.023)	(0.024)
Num.Obs.	18091	18091
Second GPA quartile		
Share peers below passing (std)	0.127***	-0.042
	(0.025)	(0.027)
Num.Obs.	18119	18119
Third GPA quartile		
Share peers below passing (std)	0.076**	-0.007
	(0.024)	(0.027)
Num.Obs.	18096	18096
Fourth GPA quartile		
Share peers below passing (std)	0.043*	-0.042
	(0.024)	(0.029)
Num.Obs.	18082	18082
Full specification controls	Y	Y
IV variable	Binary	Binary

Note: The table shows estimates for the main specification IV regression run for each subgroup of minimum-GPA quartiles in the main sample of students whose minimum GPA in Mathematics or Danish is above passing. The left-hand side is an indicator for participation in an introductory or main VET program 12 months after initial enrollment. The primary right-hand side instrumented variable is the standardized share of peers with below-passing Mathematics or Danish final exam test scores. The standardized share is instrumented with a binary treatment indicator, which takes the value one for individuals enrolled from 2015 at schools with above median shares of below-passing enrollees from lower secondary education in 2013-2014. It takes the value zero for students enrolled in below-median institutions from 2015 and the value zero for all students before 2015. Full specification controls include the student's minimum GPA in Mathematics or Danish, a female indicator, and an indicator for having at least one parent with tertiary education, fixed effects indicators for cohort year, institution, lower secondary education grade level the previous year, and the VET field the student enters. Finally, they include interactions between entered institution indicators and a continuous year variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent; ** 5 percent; * 10 percent.

Table 5: Effect of share of peers entering VET from lower secondary with below passing GPA (std.) on probability of being in Introductory or Main VET program 12 months after enrollment, controlling for institution size indicators.

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome: Intro (month 12)						
Share peers below passing	0.090***	0.080***	0.080***	0.062***	0.062***	0.063***
	(0.012)	(0.013)	(0.013)	(0.015)	(0.015)	(0.015)
Num.Obs.	72388	72388	72379	51748	51739	51500
Outcome: Main (month 12)						
Share peers below passing	-0.032**	-0.028**	-0.028**	-0.016	-0.016	-0.017
	(0.013)	(0.014)	(0.014)	(0.016)	(0.016)	(0.016)
Num.Obs.	72388	72388	72379	51748	51739	51500
Inst. size (quartic)		Y	Y	Y	Y	Y
Drop smallest 5 inst.			Y		Y	Y
Drop largest 5 inst.				Y	Y	Y
Drop inst. size < 10						Y
Full specification controls	Y	Y	Y	Y	Y	Y
IV variable	Binary	Binary	Binary	Binary	Binary	Binary
1st stage f-stat.	4959.29	4370.52	4371.15	2940.36	2940.92	2979.69

Note: The table shows 2SLS regression coefficients from regressing Introductory or Main program participation (12 months after enrollment) onto the instrumented share of peers entering VET from lower secondary education with below-passing GPAs in Mathematics or Danish. The estimation sample consists of students entering VET from lower secondary education who passed both courses. The peer shares are instrumented with a binary treatment variable taking the value one for post-reform years if the institution a student entered had a below-median share of below-passing students before the reform in 2013-2014. It takes the value zero otherwise. The quartic institution size variables are a set of size variables raised to powers 1-4, showing the number of students entering VET from lower secondary education within the year. When dropping observations based on institution size, we use the average number of entering students from lower secondary education between 2009-2014. Full specification controls include the student's minimum GPA in Mathematics or Danish, a female indicator, and an indicator for having at least one parent with tertiary education, fixed effects indicators for cohort year, institution, lower secondary education grade level the previous year, and the VET field the student enters. Finally, they include interactions between entered institution indicators and a continuous year variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent level; ** 5 percent level; * 10 percent level.

ONLINE APPENDIX

(OA) I Supplementary tables and figures

Table (OA) I.1: Main specification robustness to control variable inclusion

	(1)	(2)	(3)	(4)
Outcome: Intro participation				
Share peers below passing (std)	0.104***	0.094***	0.090***	0.097***
	(0.012)	(0.012)	(0.012)	(0.015)
Num.Obs.	72473	72473	72388	72388
Outcome: Main participation				
Share peers below passing (std)	-0.041**	-0.038**	-0.032**	-0.021
	(0.013)	(0.013)	(0.013)	(0.017)
Num.Obs.	72473	72473	72388	72388
Year FE	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y
Inst. X year (cont.) FE	Y	Y	Y	Y
Grade level FE		Y	Y	Y
VET Field FE		Y	Y	Y
Individual controls			Y	Y
Inst. X year SQ (cont.) FE				Y
F-stat (1st stage)	4944.16	4969.47	4959.29	3394.87
IV variable	Binary	Binary	Binary	Binary

Note: The table shows 2SLS coefficients from regressing Introductory or Main program participation (12 months after enrollment) onto the standardized share of peers entering VET from lower secondary education with below-passing GPAs in Mathematics or Danish, adding controls iteratively. The fixed effect control variables include a set of year and entered institution indicators, entered institution times continuous year and year squared interactions, and finally, grade level and entered VET field indicators. The individual controls include the student's own standardized GPA, an indicator for being female, and an indicator for having at least one parent with a tertiary degree. The estimation sample consists of students entering VET from lower secondary education who passed both courses. The standardized share is instrumented with a binary treatment indicator, which takes the value one for individuals enrolled from 2015 at schools with above median shares of below-passing enrollees from lower secondary education in the years 2013-2014. First-stage F-statistics show the heteroskedasticity robust F-statistic for leaving out the instrumental variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent level; ** 5 percent level; * 10 percent level.

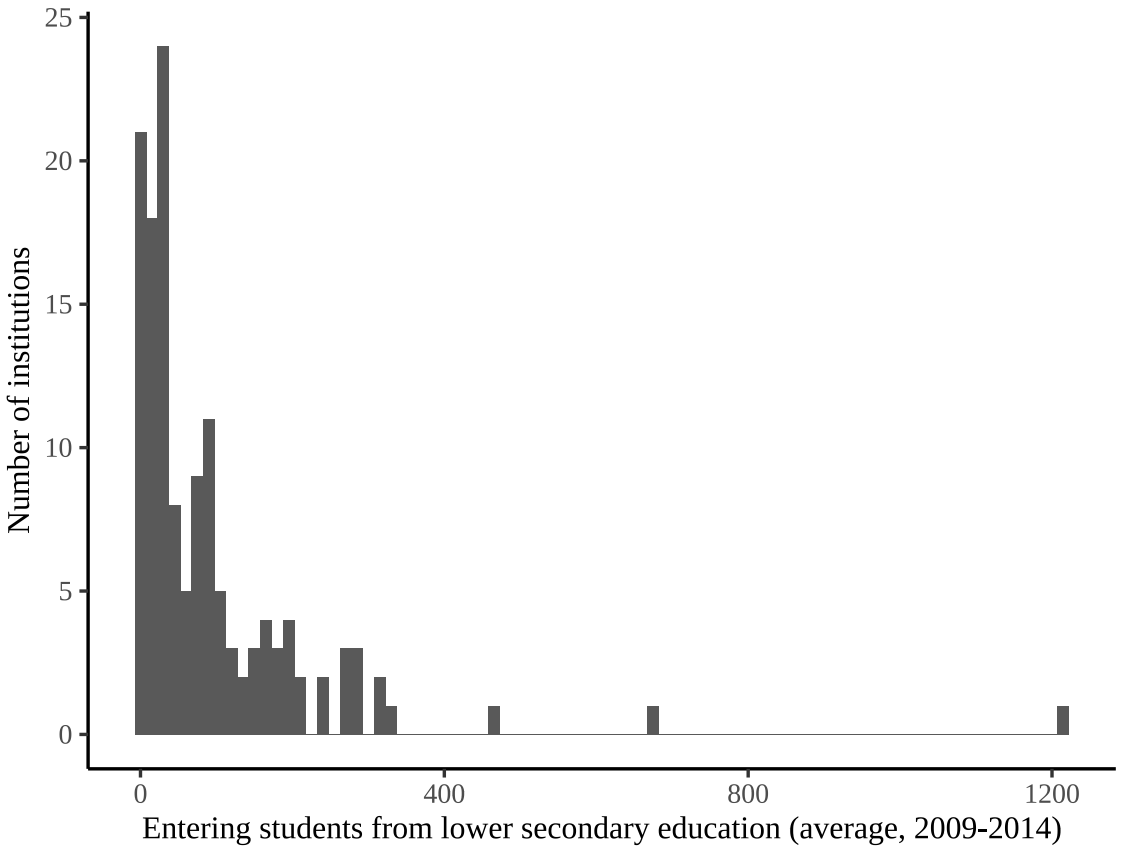


Figure (OA) I.1: Histogram of institution size measured in the average number of entering students between 2009-2014

Table (OA) I.2: IV, reduced form, and first stage estimates of below-passing peer share effect on participation in Introductory and Main VET, instrumented by continuous reform indicator.

	Intro (month 12)	Main (month 12)
IV		
Share peers below passing (std)	0.057***	-0.020**
	(0.009)	(0.010)
Num.Obs.	72388	72388
Reduced Form		
Continuous IV	-0.606***	0.216**
	(0.094)	(0.107)
Num.Obs.	72388	72388
First Stage		
Continuous IV	-10.567***	-10.567***
	(0.146)	(0.146)
Num.Obs.	72388	72388
Individual controls	Y	Y
Year FE	Y	Y
Institution FE	Y	Y
Inst. X year (cont.) FE	Y	Y
Grade level FE	Y	Y
VET Field FE	Y	Y
F-stat (1st stage)	5247.68	5247.68
IV variable	Continuous	Continuous

Note: The table shows 2SLS, First Stage, and Reduced form regression coefficients from regressing indicators for Introductory or Main program participation (12 months after enrollment) onto the instrumented share of peers entering the VET school from lower secondary education who did not pass Danish and/or Mathematics in lower secondary education, and a set of individual controls and fixed effect indicators. The estimation sample consists of VET students entering VET from lower secondary education who have passed their lower secondary Danish and Mathematics final exams. Students in Main VET have entered the apprenticeship component of the VET program, whereas students in the Intro program have dropped out of their initial program to start another program. The continuous instrument takes the value zero before 2015 and the expected share of students screened out of VET in 2015 and 2016 due to reform. The expected share is calculated as the share of 2013-2014 applicants to the institution whose minimum Mathematics or Danish gpa was below passing. The remaining right-hand-side variables include the student's own standardized GPA, an indicator for being female, and indicator for having at least one parent with a tertiary degree. The fixed effect indicators include year, grade level, entered field indicators, and entered institution indicators. They finally include entered institution times continuous year variable interactions. First stage F-statistics show the heteroskedasticity robust F-statistic for leaving out the instrumental variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent level; ** 5 percent level; * 10 percent level.

Table (OA) I.3: Variation in share of peers with below passing GPAs from lower secondary education

Statistic	N	Mean	St. Dev.
Share of entering peers below passing	73,232	0.160	0.078
”Within” share of entering peers w. below passing GPA	73,232	0.000	0.036

Note: Table shows summary statistics for share of below-passing peers to sample students who have entered VET from lower secondary education between 2009-2016 and who passed both their Danish or Mathematics lower Secondary final exams. Below-passing peers also enter VET from lower secondary education but have a below passing GPA in either or both of the subjects Danish and Mathematics. The 'within' share statistics is based on residualized peer shares, the residual from regressing the peer share onto a year indicators, entered institution indicators, and a set of entered institution indicators individually interacted with a continuous year variable.

Table (OA) I.4: Effect of share of peers entering VET from lower secondary with below passing GPA (std.) on the probability of being in Introductory or Main VET program 12 months after enrollment, controlling for institution size indicators.

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome: Intro (month 12)						
Share peers below passing	0.057***	0.053***	0.053***	0.041***	0.041***	0.042***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)
Num.Obs.	72388	72388	72379	51748	51739	51500
Outcome: Main (month 12)						
Share peers below passing	-0.020**	-0.017	-0.017	-0.002	-0.002	-0.004
	(0.010)	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)
Num.Obs.	72388	72388	72379	51748	51739	51500
Inst. size (quartic)		Y	Y	Y	Y	Y
Drop smallest 5 inst.			Y		Y	Y
Drop largest 5 inst.				Y	Y	Y
Drop inst. size < 10						Y
Individual controls	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Inst. X year (cont.) FE	Y	Y	Y	Y	Y	Y
Grade level FE	Y	Y	Y	Y	Y	Y
VET Field FE	Y	Y	Y	Y	Y	Y
IV variable	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
1st stage f-stat.	5247.68	4987.99	4988.69	3629.8	3630.5	3746.05

Note: The table shows 2SLS regression coefficients from regressing Introductory or Main program participation (12 months after enrollment) onto the instrumented share of peers entering VET from lower secondary education with below-passing GPAs in Mathematics or Danish. The estimation sample consists of students entering VET from lower secondary education who passed both courses. The peer shares are instrumented with a continuous treatment variable taking the value zero before 2015 and the expected share of students screened out of VET in 2015 and 2016 due to reform. The expected share is calculated as the share of 2013-2014 applicants to the institution whose minimum Mathematics or Danish gpa was below passing. The quartic institution size variables are a set of size variables raised to powers 1-4, showing the number of students entering VET from lower secondary education within the year. When dropping observations based on institution size, we use the average number of entering students at the institution from lower secondary education between 2009-2014. The individual controls include the student's own standardized GPA, an indicator for being female, and an indicator for having at least one parent with a tertiary degree. The fixed effect indicators include year, grade level, entered field indicators, and entered institution indicators. They finally include entered institution times continuous year variable interactions. First stage F-statistics show the heteroskedasticity robust F-statistic for leaving out the instrumental variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: * ∗ ∗ 1 percent level; *∗ 5 percent level; * 10 percent level.

Table (OA) I.5: IV, first-stage, and reduced form estimates from adding school-average controls to Introductory and Main program participation.

	2SLS		First stage	Reduced Form	
	Intro	Main	B.P. peer share	Intro	Main
Share peers below passing (std)	0.104***	−0.032**			
	(0.013)	(0.015)			
Binary IV			−0.882***	−0.092***	0.029**
			(0.015)	(0.012)	(0.013)
Num.Obs.	65 445	65 445	65 524	65 445	65 445
School controls	Y	Y	Y	Y	Y
Individual controls	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y
Inst. X year (cont.) FE	Y	Y	Y	Y	Y
Grade level FE	Y	Y	Y	Y	Y
VET Field FE	Y	Y	Y	Y	Y
F-stat (1st stage)	3550.58	3550.58			
IV variable	Binary	Binary	Binary	Binary	Binary

Note: The table shows 2SLS, First Stage, and Reduced Form estimates from the IV specification with added control variables at the individual and above-passing peers class level. The main specification regresses indicators for being in Introductory or Main program VET 12 months after enrollment on the instrumented share of peers entering VET from lower secondary education who have below passing final exam GPAs in Danish or Mathematics. The binary treatment variable takes the value one for post-reform years if the institution a student entered had a below-median share of below-passing students prior to the reform in 2013-2014. It takes the value zero otherwise. The estimation sample consist of students who have entered VET from lower secondary education with passing grades in Danish and Mathematics. The school controls include the institution-cohort average in the estimation sample of students' final grades, age at enrollment, immigrant status, mother's age at enrolment, total income, and indicators for the mother having primary education, vocational education, or tertiary education as highest education level, as well as similar averages for the father, and finally parental total log income and an indicator for at least one parent having tertiary education. The remaining control variables are the student's own minimum GPA from Mathematics or Danish, and a female indicator, as well as non-averaged versions of the school-level averaged variables. The fixed effects include indicators for cohort year, institution, lower secondary education grade level the previous year, and the VET field the student enters. Finally they include interactions between entered institution indicators and a continuous year variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent; ** 5 percent; * 10 percent.

Table (OA) I.6: IV and reduced form estimates of below-passing peer shares on participation in outside options.

	High School	10th Grade	Outside ed.
IV			
Share peers below passing (std)	-0.010	0.002	-0.023**
	(0.006)	(0.002)	(0.009)
Num.Obs.	72470	72470	72470
Reduced Form			
Continuous IV	0.105	-0.022	0.246**
	(0.066)	(0.020)	(0.098)
Num.Obs.	72470	72470	72470
Individual controls	Y	Y	Y
Year FE	Y	Y	Y
Institution FE	Y	Y	Y
Inst. X year (cont.) FE	Y	Y	Y
Grade level FE	Y	Y	Y
VET Field FE	Y	Y	Y
F-stat (1st stage)	5254.39	5254.39	5254.39
IV variable	Continuous	Continuous	Continuous

Note: The table shows IV and Reduced Form estimates from regressing indicators for being enrolled in 10th grade, Highs School, or being outside the education system on the instrumented share of peers entering VET from lower secondary education who have below passing final exam GPAs in Danish or Mathematics. The instrument is a continuous treatment variable taking the value zero before 2015 and the expected share of students screened out of VET in 2015 and 2016 due to reform. The expected share is calculated as the share of 2013-2014 applicants to the institution whose minimum Mathematics or Danish gpa was below passing. Individual controls include the student's own minimum GPA from Mathematics or Danish, a female indicator, and a indicator for having at least one parent with tertiary education. The fixed effects include indicators for cohort year, institution, lower secondary education grade level the previous year, and the VET field the student enters. Finally they include interactions between entered institution indicators and a continuous year variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent; ** 5 percent; * 10 percent.

Table (OA) I.7: Effect of share of peers entering VET from lower secondary with below passing GPA (std.) on the probability of being in Introductory or Main VET program 12 months after enrollment, controlling for total Introductory program students on November 15th.

	Intro (month 12)			Main (month 12)		
	(1)	(2)	(3)	(4)	(5)	(6)
Share peers below passing (std)	0.090***	0.090***	0.087***	−0.032**	−0.032**	−0.034**
	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)
Num.Obs.	72 388	72 371	72 371	72 388	72 371	72 371
Four size bins		Y			Y	
Eight size bins			Y			Y
Full specification controls	Y	Y	Y	Y	Y	Y
F-stat (1st stage)	4959.29	4898.01	4937.63	4959.29	4898.01	4937.63
IV variable	Binary	Binary	Binary	Binary	Binary	Binary

Note: The table shows 2SLS regression coefficients from regressing Introductory or Main program participation (12 months after enrollment) onto the share of peers entering VET from lower secondary education with below-passing GPAs in Mathematics or Danish. The estimation sample consists of students entering VET from lower secondary education who passed both courses. The peer shares are instrumented with a binary treatment variable that takes the value one from 2015 if the student's institution had a higher than median share of below-passing applicants in 2013-2014 and zero otherwise. The institution size controls are constructed by counting all individuals enrolled in the introductory VET program on November 15th in the estimation sample's enrollment year. We then create a set of indicators, splitting the set of institutions into four or eight-size bins. Full specification controls include the student's minimum GPA in Mathematics or Danish, a female indicator, and an indicator for having at least one parent with tertiary education, fixed effects indicators for cohort year, institution, lower secondary education grade level the previous year, and the VET field the student enters. Finally, they include interactions between entered institution indicators and a continuous year variable. Parentheses show heteroskedasticity robust standard errors. First stage F-statistics show the heteroskedasticity robust F-statistic for leaving out the instrumental variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: $^{*}***$ 1 percent level; $^{*}**$ 5 percent level; * 10 percent level.

Table (OA) I.8: Primary specification augmented with saturated instruments, interacting institution indicators with post-treatment period indicators.

	Intro (month 12)	Main (month 12)
Share peers below passing (std)	0.061***	−0.020**
	(0.007)	(0.007)
Num.Obs.	73 062	73 062
Individual controls	Y	Y
Year FE	Y	Y
Institution FE	Y	Y
Inst. X year (cont.) FE	Y	Y
Grade level FE	Y	Y
VET Field FE	Y	Y
F-stat (1st stage)	1358.32	1358.32
IV variable	Saturated	Saturated

Note: The table shows 2SLS estimates from regressing indicators for being in the Introductory or Main program 12 months after enrollment onto the instrumented share of peers entering the VET school from lower secondary education who did not pass Danish and/or Mathematics in lower secondary education. The saturated instruments are a set entered-institution indicators interacted individually with a post-reform indicator taking the value one starting from 2015 and zero otherwise. The estimation sample consists of of VET students entering VET from lower secondary education who have passed their lower secondary Danish and Mathematics final exams. The remaining right-hand-side variables include the student's own standardized GPA, an indicator for being female, and indicator for having at least one parent with a tertiary degree. The fixed effect indicators include year, grade level, entered field indicators, and entered institution indicators. They finally include entered institution times continuous year variable interactions. First stage F-statistics show the heteroskedasticity robust F-statistic for leaving out the instrumental variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent level; ** 5 percent level; * 10 percent level.

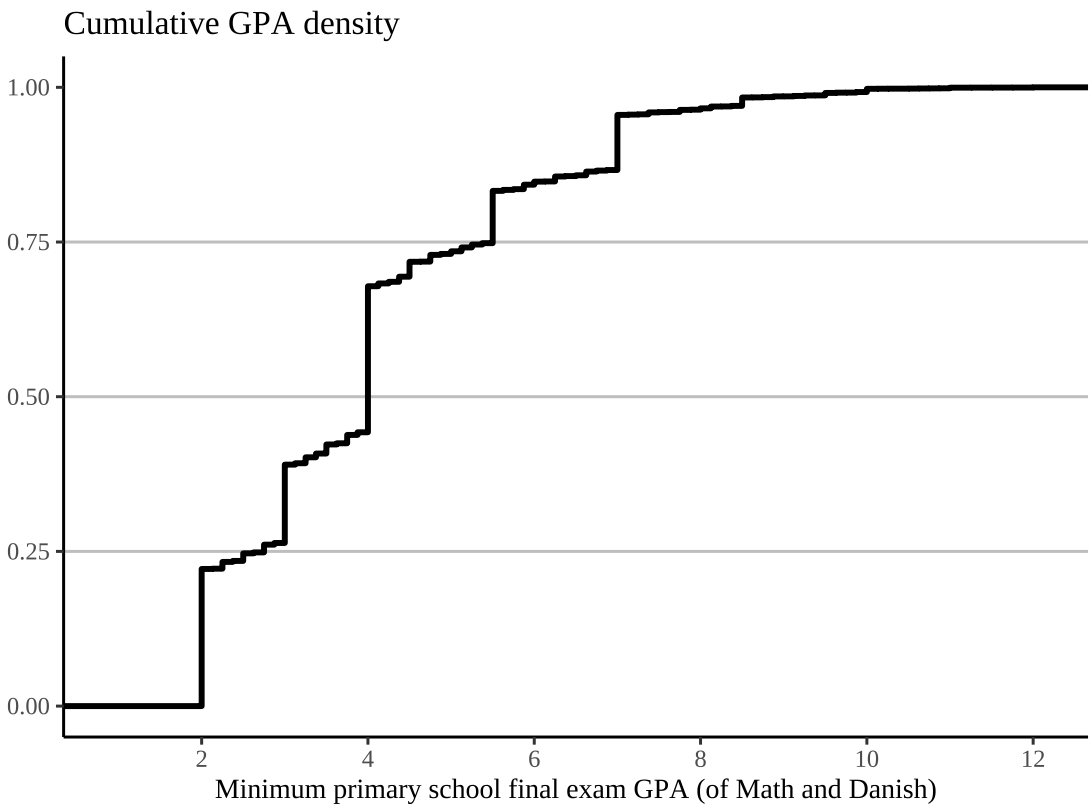


Figure (OA) I.2: Cumulative density of minimum of Mathematics and Danish GPA among passing students

Note: The figure shows the cumulative density of the minimum GPAs in Mathematics or Danish final tests among the above-passing minimum GPA students who entered VET between 2009-2016.

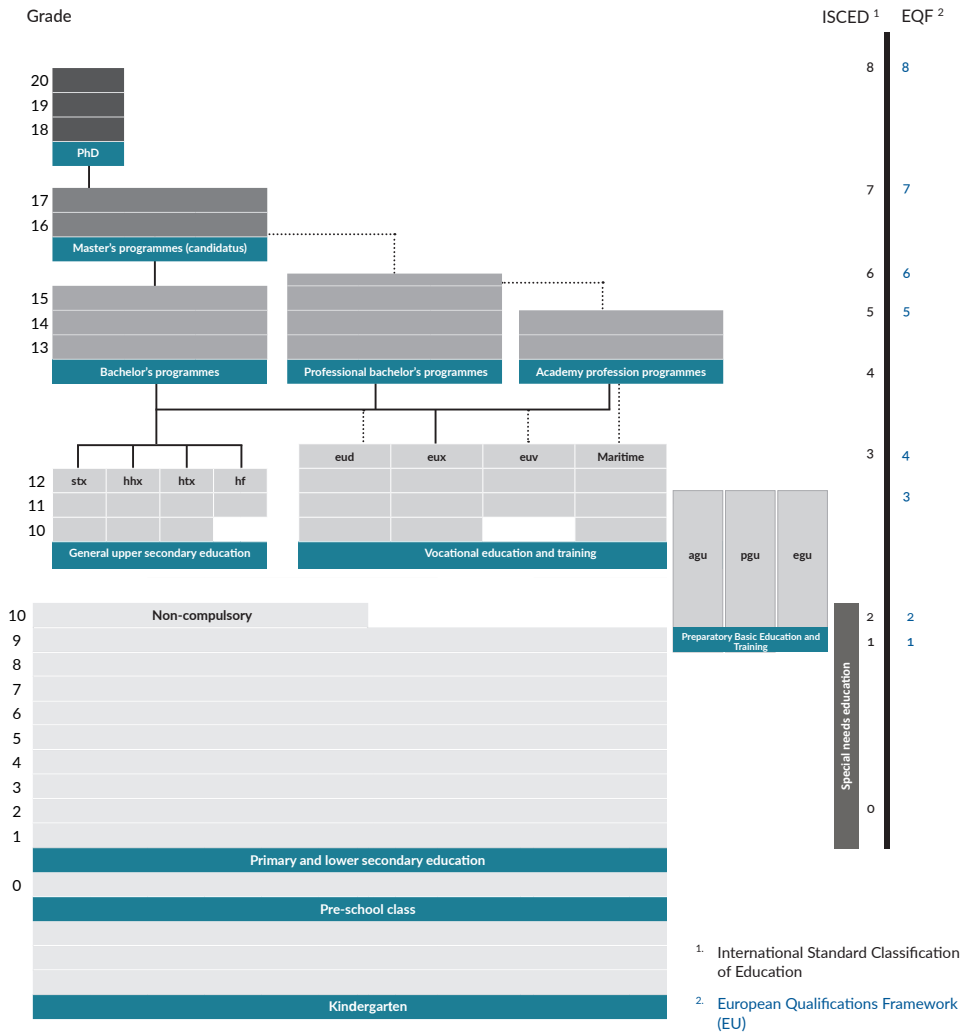
(OA) II Overview of The Danish Education System

The Danish education system is divided into three levels: primary and lower secondary school, upper secondary education, and tertiary education. Ministry of Higher Education and Science, Ministry of Children and Education, and Ministry of Culture (2021) provides a contemporary general introduction to the system and The Danish Ministry of Education (1998) surveys its historical development since the mid 19 century. Figure (OA) II.1, from the Danish Ministry of Children and Education (2020b), shows a graphical overview of the contemporaneous system, including ISCED (International Standard Classification of Education) levels associated with each type of education.

(OA) II.1 Primary and Lower Secondary

Primary and lower secondary school is mandatory from grades 0 through 9 and can be extended with an optional 10th grade. Following their final year of lower secondary school, students can either leave the education system or apply to enter lower secondary, upper secondary, or other preparatory education. The typical student will be around age 15-16 when finishing lower secondary school. Most primary and lower secondary students are enrolled in public schools (folkeskole). The remaining students are enrolled in private free schools (friskole) and boarding schools (efterskole) that typically offer 9th and 10th-grade education.

Figure (OA) II.1: The Danish Education System



Note: The illustration comes from Ministry of Children and Education (2020b).

(OA) II.2 Vocational Education and Training (VET)

Vocational and Technical educations (VET, *Erhvervsuddannelserne*) are typically vocationally oriented upper secondary programs lasting between four and four and half years, of which around three to three and a half years are spent as apprentices at firms or in public organizations. The EUD educations are supplemented by the EUX educations, which add general upper-secondary coursework to the EUD curriculum.

(OA) II.2.1 The typical EUD program

The typical EUD program consists of an introductory program and a main program. The Danish Ministry of Children and Education (2022b) provides an overview of the program structure.

The introductory program The introductory program consists of two parts. The first part introduces students to their chosen main field's core theory and practical tools. Only students who enter VET directly from 9th or 10th grade enter part one. Part two contains more program-specific courses with applied and theoretical focus. Students are also expected to search for apprenticeship positions during the second part of the program if they have not already found a position. Students enter part two if they have completed part one, have found an apprenticeship before entering VET and wish to skip part one, have participated in previous VET education, or enter VET from outside the education system.

The main program The main program structure depends on which VET education the student enters but typically lasts between two and three and half years, during which the

student interchangeably learns in an apprenticeship position in a firm and at a VET school. The length and content of the school periods depend on the individual program. It is a requirement for nearly all main programs that the student has found an apprenticeship position in a firm before they can start the main program. Students who have attempted to find an apprenticeship without luck can enter into school apprenticeship under the condition that they continue to search for apprenticeships and are willing to take apprenticeship positions in other fields if their VET school finds one for them. Table (OA) II.1 shows, based on data from the Danish Ministry of Children and Education (2020c), that only between 9.2 and 6.7 percent of all ongoing apprenticeships were school-based between 2017 and 2019.

The apprenticeship period begins with a three-month trial period, during which both the student and the firm can end the apprenticeship contract. The typical main program lasts three years and ends with the student taking a final exam.

Table (OA) II.1: Number of ongoing apprenticeships, November

	2017	2018	2019
Private/Public apprenticeships	66,954 (90.8 pct)	68,274 (92.71 pct)	71,053 (93.35 pct)
School-based apprenticeships	6,784 (9.2 pct)	5,365 (7.29 pct)	5,058 (6.65 pct)
Total	73,738	73,639	76,111

Note: The table shows all ongoing apprenticeships in November by whether the apprenticeship takes place in a firm or public entity, or at a VET school. Percentages are calculated within years. The data was collected from Ministry of Children and Education 2020c.

New Master Teaching (Ny Mesterlære) Students can void the initial school-based introductory program if they have an apprenticeship position with a firm willing to train them during the program's initial year. The student spends three days in the firm and two days

in school each week during the first year. Their learning trajectory is assessed through an examination at the school, and they enter the formal main program if they pass.

School-apprenticeship (Skolepraktik) Students who have applied for but were unable to find an apprenticeship at a firm may be eligible for a school-based apprenticeship, where the students are taught skills analogous to those the student would learn in a firm-based apprenticeship (Ministry of Children and Education 2022d). To be accepted into a school apprenticeship, the student must be able to document that they have attempted to find an apprenticeship position. The requirements include (1) having a profile on the online search portal for apprenticeship positions (lærepladsen.dk); (2) having searched actively for apprenticeship positions during the whole introductory program; (3) documenting the process search in the personal education plan at the VET school. To remain in the school apprenticeship, the student must continue searching and applying for job positions in firms. If offered a position, they must be prepared to take it regardless of where in the country the position is located and if the apprenticeship specialization matches their preference. Students unwilling to accept the conditions for school apprenticeships can re-enroll in a different introductory program. They will typically enroll in the second part of the introductory program. It is only possible to re-enroll in this way two times unless the student finds an apprenticeship between entering the new program.

EUX (integrated general upper secondary education and VET) EUX education is an integrated general upper secondary end VET program categorized as a VET program by the Danish Ministry of Education. Students are required to follow the regular courses required for VET students, including an introductory program. The EUX educations were

first offered in 2010 by four VET schools. By 2014, the first cohort of EUX students graduated from the program (Pinborg 2014). The number of VET educations offered with EUX tracks grew to 25 programs in 2014 and 36 in 2015. In an interview with the Danish news media "Gymnasieskolen"[25] Education counselors at a VET school suggested that the type of students applying to VET are, in general, ambitious and academically well-performing but prefer *applied subjects over Greek Mythology* (Buch 2015).

The EUX students participate in the introductory programs and VET courses like the regular VET students, suggesting a potential peer effect from these students on the regular VET students. Unfortunately, our administrative datasets do not allow us to discern EUX students from regular VET students before 2015, although the program started earlier. We, therefore, include EUX students with regular VET students for the main analyses and leave further analyses of the EUX education for future research using more detailed information on the EUX education.

(OA) II.2.2 Access to EUD

Before the summer of 2015, applicants to VET would be admitted subject to limitations on slots in the particular program applied to. Applicants come from lower secondary education and outside the education system. The 2015 EUD reform introduced a new GPA cutoff for direct access to EUD education, meaning that only students who passed their Danish and Mathematics lower secondary final exams had direct access to tertiary education.[26] Non-passing applicants can take additional tests to show proficiency in the two subjects and

[25] "Gymnasieskolen" is a print media with nine annual circulations covering various aspects of upper secondary education. The target audience is general upper secondary teachers.

[26] The GPA in Mathematics and Danish are calculated according to the formula set by the Danish Ministry of Children and Education (2020a).

may be admitted if they pass.

(OA) II.2.3 Access to further education

EUD educations give access to a limited set of professional bachelors depending on the type of EUD degree obtained but do not give direct access to university degrees (see Ministry of Children and Education 2021).[27] In many cases, students will have to take additional credits to enter a certain vocational bachelor.

(OA) II.2.4 Program dropout

A substantial share of students who enroll in VET do not finish their studies within five years, and many drop out of VET programs entirely. Figure (OA) II.2 is based on data from Statistics Denmark (2022). and shows that between 32 and 45 percent of those individuals who enrolled at age 17 or less in VET between 2008 and 2016 dropped out five years later. The percentage of students who get a degree within five years remained around 43 percent for all cohorts.

The sizeable overall dropout rate after five years is partly due to a high share of students who do not enter the main program, even conditional on completing the introductory program. Figure (OA) II.3 shows that an average of 38 percent of students who were enrolled in introductory VET aged 17 or less and completed the program had not entered a main program three months later between the years 2011 to 2017, while the share is 36 percent six months later. The share who had entered a main program by entering an apprenticeship

[27] Ministry of Children and Education (2022a) shows what tertiary educations each upper secondary education gives access to. EUD educations lasting longer than three years typically give access to a range of professional bachelors.

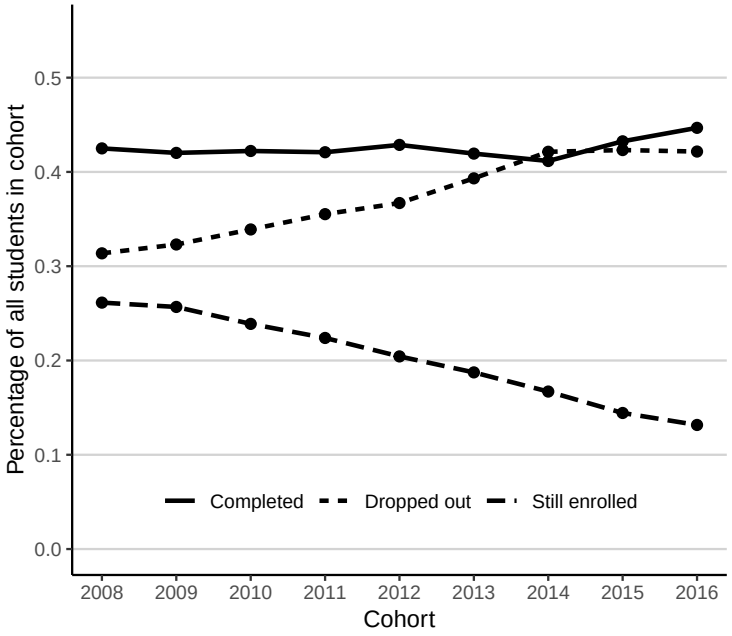


Figure (OA) II.2: Completion status five years after enrollment in VET for age 17 or younger starters

Note: The figure shows the education status of those students who enrolled in VET when aged 17 or younger between 2008 and 2016. The data is collected from Statistics Denmark (2022).

in a firm or public organization was 49 percent by month three and 53 percent by month six. The remaining 13 and 10 percent were enrolled in school-based apprenticeships.

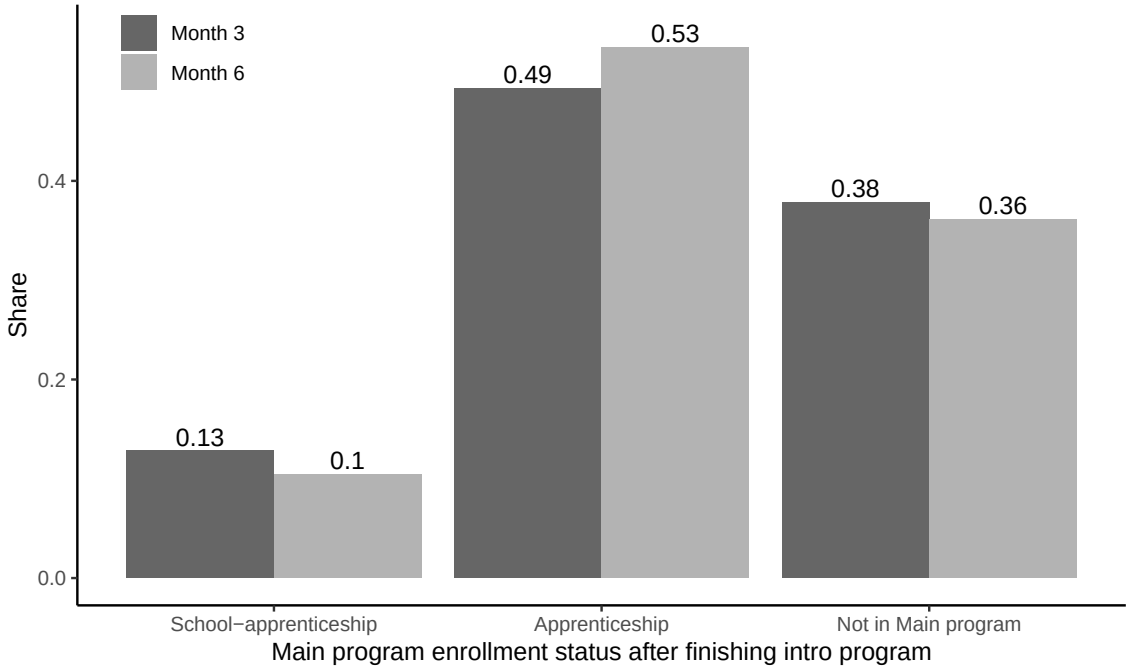


Figure (OA) II.3: Main program enrollment status three months after introductory program graduation between 2011-2017

Note: The figure is based on data from Ministry of Children and Education (2022e) and shows the share of VET introductory program graduates who are enrolled in main program apprenticeships in firms or public organizations, enrolled in apprenticeships within schools, or have not entered a VET main program. The sample is limited to individuals aged 17 or less when enrolling in the introductory program.

(OA) II.2.5 The 2015 VET reform

The 2015 Danish VET reform, "Better and More Attractive Vocational Educations" (Bedre og mere attraktive erhvervsuddannelser mv 2014) is the result of a political agreement

reached by a broad political coalition on February 24, 2014, (Regeringen 2014). The background for the agreement was high dropout rates and low shares of lower secondary graduate applications to the VET programs, according to the agreement. The primary goals of the reform were (see Slottved et al. 2020).

1. More students must choose the vocational education following 9th or 10th grade.
2. More students must complete a vocational education.
3. Vocational education should challenge the students so they become as skilled as they can.
4. The trust and welfare of vocational schools must be strengthened.

One of the primary tools used to reach the goals was introducing a GPA requirement, meaning that applicants had to have a passing GPA in Danish and Mathematics from the official final exams in lower secondary school to be accepted directly into the VET programs. Applicants who did not meet the requirement could be admitted if they took and passed an entrance exam in the subject not passed initially or if the student had found an apprenticeship position with a firm.

Previous evaluations

VIVE, The National Center For Social Science Research, was tasked with evaluating the implementation of the 2015 reform with respect to the main targets of the reform and published three reports with evaluations of the introductory and main program reform components.

The report ”Introductory Programs in the Vocational Educations Three Years After The Reform” (”Grundforløb på erhvervsuddannelserne tre år efter reformed”) by Slottved

et al. (2020) investigates the experiences of students, teachers and school leadership of the introductory programs by 2020. The report is based on a combination of interview and administrative data analyses and finds that the VET schools generally were successful in implementing the structural components of the reform, including the entrance GPA requirement. However, some schools were less successful in improving student learning and thriving in programs. Students at larger VET schools generally answered less positively on student welfare evaluations than those from smaller schools. The greater schools were also less successful in implementing the 45 minutes of physical activity required by the reform. The structural changes were most likely implemented in the first year after reform onset, as the findings from the three-year evaluation show results similar to those from an evaluation made by KORA in the first year following the reform (Søndergaard et al. 2017). This also implies that little has changed in the VET institutions over the three years since the reform was implemented.

VIVE also evaluated how the reform affected students and teachers on the VET main programs in 2018 (Koudahl 2018) in the report ”Main programs in the vocational educations after the reform” (”Hovedforløb på erhvervsuddannelserne efter reformen”). The reform goals for the main programs were to improve teachers’ teaching competencies, increase their use, and link school and apprenticeship learning better. The report is based on surveys sent to and interviews with teachers, students, and school management, as well as descriptive analysis of administrative data. The main findings in the report are that while half of teachers had participated in courses aimed at up-qualifying teaching skills, many found it challenging to implement IT and restructure their teaching. The teachers also found it challenging to make the teaching in the main program better linked to apprentice-

ship learning, particularly as students in different types of programs (school apprenticeships, apprenticeships, EUX, and students above the age of 25) all participated in the same courses. It is plausible that the average teaching quality only improved to a very limited extent in the main programs.

Larsen, Andersen, and Larsen (2022) studies criminal activities among 9th-grade male graduates within nine months after graduation before and after the 2015 reform, comparing students below the cut-off with students above the cut-off. They found that the below-passing students became 17 percentage points less likely to enroll in upper secondary education after reform and, on average, became two percentage points more likely to have been charged with committing a crime within nine months after graduation from lower secondary education. They also calculate an education-crime elasticity of 0.69, meaning that the academically lower-performing students become 0.69 percent more likely to commit crime for each percentage decrease in upper secondary education enrollment.

(OA) II.3 General upper secondary education

General upper secondary education lasts between two and three years, and students can choose between four different programs defined by their emphasis: the general STX, the mercantile HHX, the technical HTX, which all last three years, and the two-year HF (Ministry of Children and Education 2022c). All four programs give access to tertiary education, if the student passes required classes in upper secondary education and has a GPA a certain threshold for som tertiary programs. The HF primarily gives access to vocational and professional tertiary education, whereas the remaining three programs also give access to university programs.

(OA) II.3.1 Dropout

Nearly all students who start general upper secondary education have completed an upper secondary degree in five years. Figure (OA) II.4 uses data from Statistics Denmark (2022) to show that nearly 90 percent of those who aged 17 or less who enrolled in general upper secondary education between 2008 and 2016 had completed the program within five years. Only 11 percent had not obtained a degree, and less than a percent were still enrolled in general upper secondary education.

(OA) II.4 Applying to education from 9th and 10th grade

Students in lower secondary 9th or 10th grade can apply to enroll in 10th grade, upper secondary, and other preparatory education by submitting an 'education plan' containing their application through the online webpage 'www.optagelse.dk' no later than March 1st (Ministry of Children and Education and Styrelsen For IT og Læring 2022b).[28] The application can contain up to 5 ranked education wishes, a combination of a program and institution. Students applying to VET must choose a main area (hovedområde) and a program within the main area. In contrast, applicants to general upper secondary education only choose a main direction (STX, HHX, HTX, HF). After students apply, their lower secondary school adds additional information, including a mandatory education-readiness assessment and preliminary grades from the first half of the school year, which the application institution uses to assess the student for acceptance. Following the 2015 VET reform, if a student

[28] The Danish Ministry of Children and Education provides online guidance for students, parents, schools, and other institutions about the application process through their website (Ministry of Children and Education and Styrelsen For IT og Læring 2022b) and on the content, administrative characteristics, and application processes and requirements through their Education Guide website at www.ug.dk.

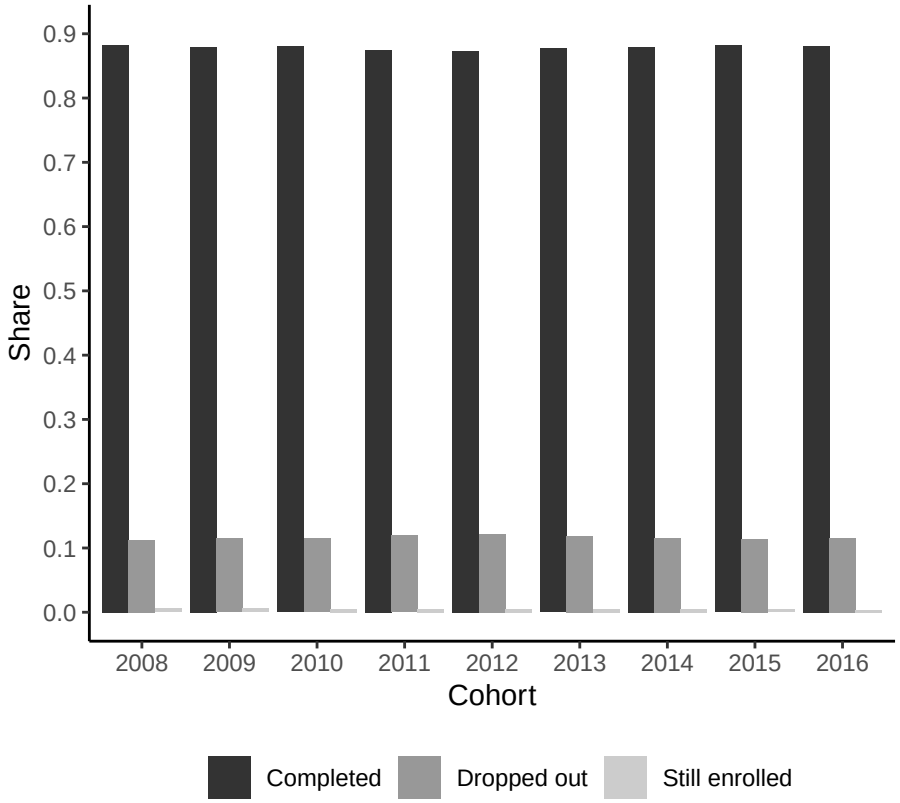


Figure (OA) II.4: Completion status five years after enrollment in general upper secondary education for age 17 or younger starters

Note: The figure shows the education status of those students who enrolled in general upper secondary when aged 17 or younger between 2008 and 2016. The data is collected from Statistics Denmark (2022).

applies to a VET program, the school will also submit the student's final grades in Danish and Mathematics when they receive these in June.

After students submit their application and their school adds preliminary grades and assessments, the student's first ranked-choice receives the application and decides whether to admit the student. At VET schools, students would be admitted if there were sufficient

open spots in the education program before the 2015 reform and were required to pass final Danish and Mathematics tests or additional retests after the reform to be admitted. The head of general upper secondary institutions decides whether to admit applicants, subject to the official ”admissions declaration” from the Ministry of Children and Education (see Optagelsesbekendtgørelsen 2020, for a recent version). Since 2016, students were required to have a sufficiently high GPA from their lower secondary education to be directly admitted and alternatively to have a conversation with the head of the admissions institution, explaining why they wish to be admitted (Gymnasieloven 2016).

The application process has remained broadly similar since 1991 when the Ministry of Education issued the first procedural guideline for education applications from 9th and 10th graders (Bekendtgørelse om vejledning og om tilmelding til ungdomsuddannelserne for elever i folkeskolen mv 1991). The significant changes to the application system involved by year of implementation:

2005 a shift from paper-based applications to online applications via ‘www.optagelse.dk‘ for those students who preferred it over the paper application.

2008 a shift from students being able to list nine preferences to only 5, admissions decisions at general upper secondary institutions should follow the ”admissions declaration.”

2010 The application becomes an integrated part of the student’s ”education plan,” the application process shifted entirely to the online system via ”www.optagelse.dk,” and the application deadline is shifted from March 15 to March 1. For students who apply to a public school, 10th grade gets the right to admission, whereas admission

to other 10th-grade programs remains subject to the institution's decision.

2012 Students who apply to general upper secondary education must list at least two additional preferences.

2014 Students who apply to VET in the following year are affected by the 2015 VET reform, implementing a GPA requirement of a passing grade (2.0) in both Danish and Mathematics for direct entry.

Figure (OA) II.5 shows the distribution of 9th and 10th graders priority applications for those who applied between 2012/2013 and 2021/2022. Table (OA) II.2 shows the yearly distribution. Both are based on data from Børne- og Undervisningsministeriet (2022). Nearly one in two 9th graders apply to the optional 10th grade, while two in five apply to enter general upper secondary education. Only 8 percent apply to enter vocational education and training. Among the 10th graders, nearly 70 percent apply to general upper secondary education, and nearly two in five apply to enter vocational education and training. The shares are relatively stable over time, except that 10th graders have become three percentage points more likely to apply to general upper secondary education and similarly less likely to apply to VET from 2020, as the global pandemic resulted in extensive lockdowns in Denmark. 9th graders' application pattern to VET remained relatively stable. In contrast, five percent more students applied to enter 10th grade, and nearly the same percentage points stopped applying to general upper secondary education from 2015 to 2022.

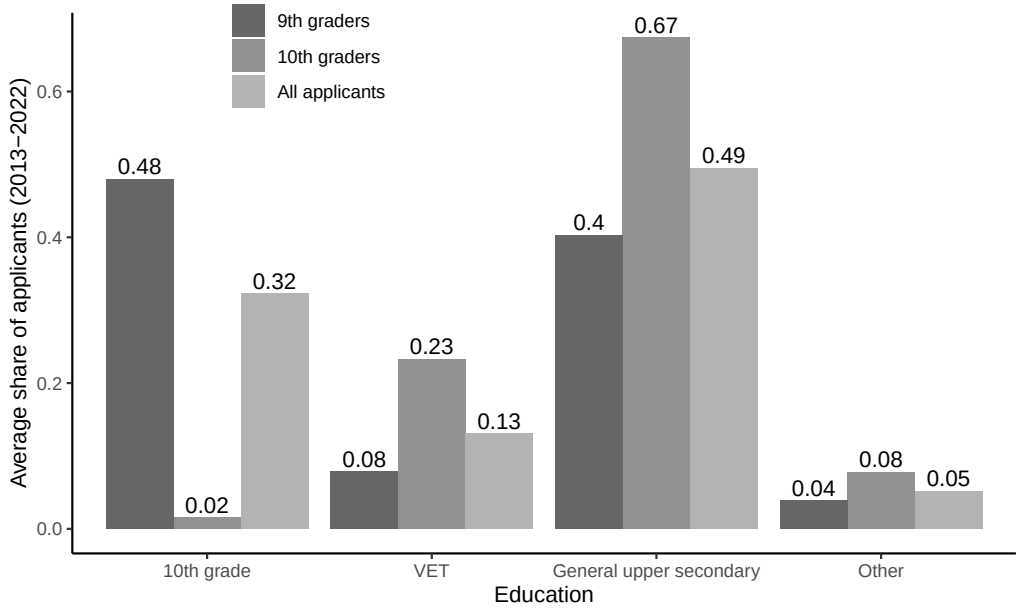


Figure (OA) II.5: Average share of 9th and 10th grade applicants ranking education highest, 2012/2013 to 2021/2022 cohorts

Note: The figure shows the average share of students applying to a given type of education with first priority from 9th or 10th grade across the school years 2012/2013 to 2021/2022. The category *All applicants* pools students from both grade levels. The data comes from Børne- og Undervisningsministeriet (2022)

(OA) II.5 Grading system

Grading in the Danish education system follows a 7-point grading scale. Table (OA) II.3 from the Danish Ministry of Higher Education and Science (2021) illustrates the grading scale with a description of the performance associated with each level and an official translation to the international ECTS letter-graded system. The table also shows a translation from the 7-point scale to the 13-point scale used from 1971 until July 2006 in lower secondary education and general upper secondary education, and until July 2007 in Vocational Education and Training and tertiary education (Ministry of Higher Education and Science

Table (OA) II.2: 9th and 10th graders highest ranked education in application by year

	Year									
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
10th graders										
10th grade	1.70	1.46	1.75	1.59	1.53	1.55	1.66	1.22	1.79	1.27
VET	23.41	24.28	23.20	23.62	23.58	24.21	24.31	22.73	21.80	21.41
General upper secondary	67.43	66.70	67.39	67.14	66.87	65.87	65.62	68.67	68.74	69.91
Other	7.47	7.56	7.65	7.65	8.02	8.36	8.41	7.39	7.67	7.41
9th graders										
10th grade	48.34	48.26	48.21	45.42	46.11	46.18	47.03	47.83	50.76	51.82
VET	7.18	7.57	7.00	7.13	7.28	7.80	8.37	8.73	8.58	8.68
General upper secondary	40.53	40.47	40.90	43.68	42.87	42.48	40.69	39.53	36.68	35.00
Other	3.95	3.70	3.88	3.77	3.74	3.53	3.91	3.92	3.98	4.50

Note: The table shows the distribution of students' first priority education in their education applications by school year from 2012/2013 to 2021/2022. The data is collected from Børne- og Undervisningsministeriet 2022 and does not include information on the share of 9th and 10th graders who did not submit any applications.

2020). A grade of 02 is a passing grade, 00 and −03 are below passing. The grades 4, 7, and 10 are given for below-average, average, and above-average performance. The highest grade, 12, is given for excellent performance with no or only a few minor weaknesses.

Table (OA) II.3: The Danish 7-point grading system

Grade	Description	ECTS	Old scale (00-13)
12	For an excellent performance displaying a high level of command of all aspects of the relevant material, with no or only a few minor weaknesses	A	13, 11
10	For a very good performance displaying a high level of command of most aspects of the relevant material, with only minor weaknesses	B	10
7	For a good performance displaying good command of the relevant material but also some weaknesses	C	8, 9
4	For a fair performance displaying some command of the relevant material but also some major weaknesses	D	7
2	For a performance meeting only the minimum requirements for acceptance	E	6
0	For a performance which does not meet the minimum requirements for acceptance	Fx	5
-3	For a performance which is unacceptable in all respects	F	3, 00

Note: The table shows the Danish 7-point grading scale with descriptions, international comparisons, and an indicative translation to the previous 13-point scale compiled by the Danish Ministry of Higher Education and Science 2021. The 13-scale was used until July 2006 in lower and general upper secondary and July 2007 in Vocational Education and Training and tertiary education Ministry of Higher Education and Science 2020.

(OA) III VET across the OECD countries

The OECD countries differ substantially in the shares of upper secondary education students in combined school and work-based VET (OECD 2010).[29] Denmark stands out with Germany, Switzerland, Austria, The Czech Republic, and Slovakia as countries with a high share of combined school and work-based upper secondary students. Belgium, Sweden, the United Kingdom, Turkey, Korea, Italy, Finland, and the Netherlands have relatively high shares of school-based vocational and technical students. Eichhorst et al. (2015) contains an overview of VET structures across various OECD countries.

(OA) III.1 Dropout rates

Dropout rates are typically measured in different ways across countries, making it challenging to make international comparisons (Bôhn and Deutscher 2022; Lyche 2010). Cedefop (2016b) states that European statistics on dropout rates have not been able to separate Vocational Education and Training from general upper secondary education at least up to 2016. One solution to learn more about dropout rates from VET across multiple countries is to collect nationally specific statistics despite their relative in-comparability.

Available evidence

Dropout is a major challenge for virtually all countries, and vocational programs typically face higher dropout rates than general education. Policies

[29] OECD (2010) contains an introduction to VET systems in the OECD countries at an overall level, with emphasis on similarities between countries, for example, in the share of upper secondary students in VET programs or expecting to be employed in high skill blue-collar jobs. Their numbers on shares of combined work and school and school-based VET come from OECD (2008), Education at a Glance 2008: OECD Indicators, Table C1.1, OECD, Paris.

> *include a provision to retain students in education and training and second chance opportunities for those who dropped out (see Box 1.6). For an OECD review on overcoming dropout from upper secondary education (see Lyche, 2010, forthcoming).* OECD 2010, p. 37

Vocational education and training programs across the OECD countries are challenged by high dropout rates, which typically exceed that in general education and are cited by OECD 2010, p. 37, as one of the significant challenges for VET programs. Bôhn and Deutscher (2022) similarly motivate their meta-study of VET dropout with high dropout rates across OECD countries, and Le Mouillour (2017) describe high dropout rates as problems facing both Austria, Denmark, and Germany, compelling the former two countries to reform their VET educations to reduce the problem.

While national data on dropout rates can be challenging to collect, the general picture appears to be that dropout rates in VET programs are high, and exceeding those in general education programs. Cedefop (2016a) uses the AES survey to investigate early leavers from education programs across 16 countries, finding suggestive evidence that the dropout rate from VET programs is typically up to double that of general education programs.[30] Cedefop (2016a) also use national sources to provide suggestive evidence that 20.5 percent of those who enrolled in pre-VET pathways in the Netherlands in 2004 had no degree beyond lower secondary education by 2014. For those who enrolled in VET in Flemish Belgium, the rate may be up to 37 percent of VET students in apprenticeships, and 24 percent of all individuals leaving VET in France in 2014 had not completed their program, while 20.5 percent dropped out in the Netherlands in 2005 (Cedefop 2016a, p. 52).

[30] The survey data have a high non-response rate, and may therefore not be representative of actual outcomes. Cedefop (2016a) expect that the dropout rates may in fact be understated.

In Denmark, more than 40 percent of students dropped out of the VET program within five years from starting their typically four to four-and-a-half-year program between 2008 and 2016 (Statistics Denmark 2022). In Norway, between 27.6 and 16.2 percent of all students enrolling in vocational upper secondary education from 2006 to 2015 dropped out within five years, while only between 8.3 and 3.5 percent dropped out from the general upper secondary programs (Statistics Norway 2022). According to Bôhn and Deutscher (2022, fn 1), Australia has a dropout rate of 58.6 percent from vocational education and training.

In Germany, around one in four apprenticeship students terminate their contracts before receiving their degrees (BIBB 2013, table A4.7-2; Wydra-Somaggio 2021). Wydra-Somaggio (2021) study apprenticeship leavers using the Ausbildungspanel Saarland, 1999-2003, and shows that nearly 70 percent of apprenticeship leavers stop out, leave to start another apprenticeship or VET program. Still, around 45 percent of initial leavers have left the VET system by the end of the study period.

There may also be substantial heterogeneity in dropout rates across VET programs. Cedefop (2016a) provides evidence on premature contract termination in the German education system in 2011[31], where between 43 and 51 percent of contracts in professions such as restaurant management, cooking, hairdressing, and hospitality. In contrast, apprentices in administrative, electrician, technical systems and products, and chemical technician professions have 2.7 and 6.9 percent termination rates.

[31] The data comes from BIBB (2013).

(OA) IV Data preparation description

(OA) IV.1 Test Scores

The 2015 VET reform set GPA requirements on minimum GPAs in final Danish (Danish) and Mathematics test scores from standardized final exams taken in May and June in 9th or 10th grade. Until 2018, the GPA in Danish is calculated as the simple average of Oral, Reading, Writing, and Spelling test scores for 9th-grade students and Oral and Writing test scores for 10th-graders. The average test scores in mathematics are calculated as the average problem-solving with aid and problem-solving without aid in 9th grade and the problem-solving grade in 10th grade. The minimum grade used to determine access to VET is the minimum of the average Danish and Math scores.

We create these subject-specific minimum GPAs using data from the ”UDFK” register from Statistics Denmark. The register contains both final and preliminary test scores from 2002 to 2017, and we limit the sample to students taking final exams between 2009 and 2016. To calculate minimum GPAs, we pick all test scores received in final exams, removing observations with no observed grade, e.g., due to the student being sick at the time of the exam. We then calculate the average test scores in Mathematics and Danish according to the Government calculation scheme and find the minimum of the averaged Mathematics and Danish test scores.

We also calculate minimum GPAs using preliminary scores based on teacher assessments of student learning given in the first semester of the school year. Preliminary test scores are given independently of final test scores. They are only used as a means to indicate to the student the teacher’s assessment of their subject-specific knowledge in Danish

and Mathematics.[32] They are, therefore, unlikely to be subject to manipulation by either teachers or students who want to ensure that the students manage to enter a VET education.

The distribution of final and preliminary GPAs for students who enter VET from primary school can be seen in figure (OA) IV.1. Most students pass either or both of the Danish and Mathematics courses, but a substantial share of students do not.

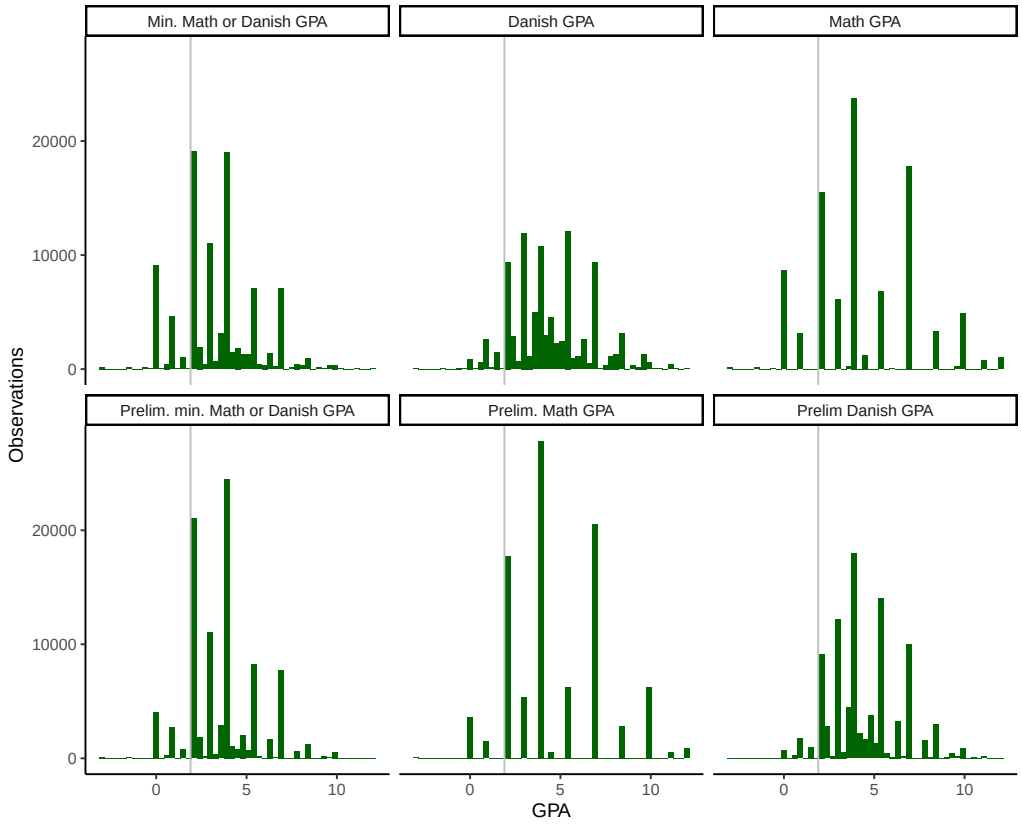
(OA) IV.2 Education enrollment

Our analyses focus on whether students are enrolled in introductory or Main VET after the first year in their education program. We collect information on education enrollment from the ”KOTRE” register from Statistics Denmark, which contains spells of education at all officially registered educations in Denmark for all participants, starting from the early 1970s to the fourth quarter of 2017. Because all formal education is observed in the register, the register comprehensively covers education participation. Education not included is limited to privately offered courses, such as employee development courses within firms, that give no formal qualifications. Each entry in the register corresponds to an education spell and contains a student ID, the start and end of the spell, the level of pursued education, the type of education pursued, the institution at which the education is pursued, and, notably, the part of the program pursued, including introductory or main programs in VET.

We construct monthly information on educational enrollment for all students appearing

[32] Preliminary test scores are converted to final test scores for subjects without mandatory final exams if the student's class is not picked (at random) by the Ministry of Education to sit final exams in the subject. This happens as 9th and 10th-grade students only sit final exams in several subjects less than all they have studied. However, this preliminary conversion to final grades cannot happen for the mandatory Danish and Mathematics classes.

Figure (OA) IV.1: Final and preliminary GPA in Mathematics, Danish, and their minimum for students who entered VET.



Note: The figure shows GPAs for all students who entered VET from primary school in Denmark from 2009 to 2016. GPAs in Danish and Mathematics are calculated among mandatory tests in the subjects. Final GPAs are students' GPA in mandatory final subject tests administered by the Danish Government and graded by the subject teacher and an external examiner. Preliminary GPAs are based on subject teachers' performance evaluation within the class and in a preliminary test administered by the Danish Government halfway through the school year.

in the grades and application data from the KOTRE data for each month after expected enrollment in VET after finishing 9th or 10th-grade education. The data includes indicators for whether the student is enrolled in VET, introductory VET, or main VET programs, general upper secondary education, lower secondary education, and other types of education. We also construct an indicator variable for being outside the official education system, taking the value one if the student is not observed in KOTRE.[33] Because we only observed education participation until the end of 2017, we stopped the education spell registration after this month. Figure (OA) IV.2, shows the number of months of available data for each cohort graduating from either 9th or 10th grade, and the number of student observations.

(OA) IV.2.1 EUX - integrated VET and academic High School

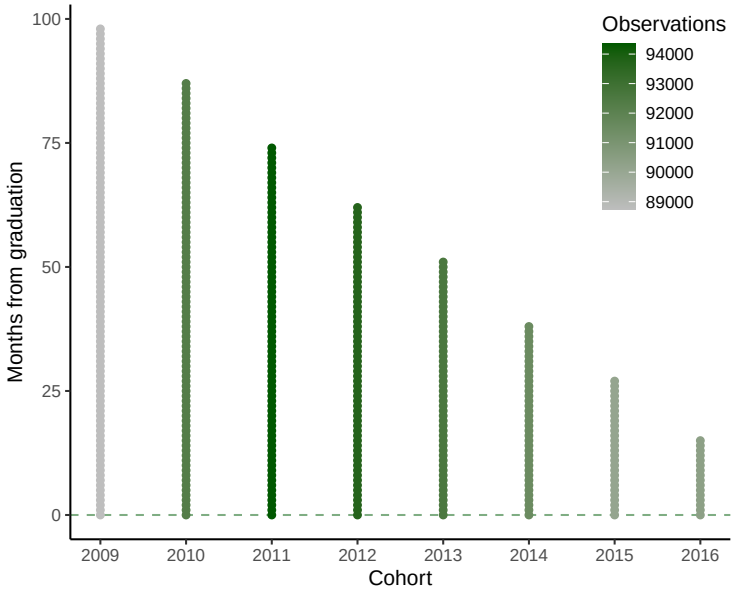
While most VET programs emphasize applied skills, a small group of education, EUX, integrates Gymnasium (High School) coursework and Vocational Education and Training programs, although recognized as VET programs. The EUX programs started in 2010 and are officially recognized as VET programs as students follow the regular courses required for VET students, including an introductory program.[34] The EUX students may differ from the average student in our analysis due to positive selection on academic abilities.[35] This

[33] Because of the comprehensive coverage of the KOTRE register, the student is likely not to be pursuing any education, formal or otherwise when they do not appear in KOTRE.

[34] Information about the Danish EUX programs is available at https://www.uvm.dk/erhvervsuddannelser/uddannelser/eux/om-eux. The EUX education started in 2010 with four schools offering integrated VET and High School education, and by 2014, the first cohort of EUX students graduated from the program (Pinborg 2014). The number of educations offered as EUX tracks has since grown to include 25 programs offered in 2014 and 36 in 2015.

[35] In an interview with the Danish news media "Gymnasieskolen," which cover High School education news and whose main readers are upper secondary teachers, education counselors at a VET school suggested that the type of students applying to VET are in general ambitious and academically well-performing, but prefers applied subjects over Greek Mythology (Buch 2015).

Figure (OA) IV.2: Coverage of the education spells data in months from primary school graduation for students in a complete sample of graduating students with GPA data.



Note: The figure shows the number of students observed and the number of months of available information on education participation spells for each cohort of primary school graduates in the main dataset. The dataset also covers periods in which the individual is not in any education program.

would make a sub-analysis of this group of students particularly interesting, as removing the low-GPA students from the peer group may benefit these students. Unfortunately, our administrative datasets do not allow us to discern EUX students from regular VET students before 2015, although the program started earlier. We, therefore, cannot perform the sub-analysis for the EUX students separately for the full period; instead, we group them with regular VET students in the analysis.

(OA) IV.3 Applications

We obtained data on students' applications to education from 9th and 10th grade from the Danish Ministry of Education, containing the information registered by the Ministry from students' applications sent through the website "www.optagelse.dk," which all students must use to submit their applications.

The original application data contains all education applications by lower secondary from the 2008/2009 cohort to the 2016/2017 cohorts. Each entry in the data is an application by a student with a priority rank between 1 and 5. Student identifiers in the data allow us to link the application data to the administrative data from Statistics Denmark. For each entry, we observe the year and month the application is submitted, the type of education applied to (general upper secondary, VET, lower secondary 10th grade, or other), the grade level of students, the institution the student applies from, the institution the student applies to, and the home municipality.

We use the application data to identify those students who initially applied to VET and the institution to which they applied. To do this, we select the highest-ranked application for each 9th and 10th-grade student each year, where the student sent the application

within the first three months of the school year. We add the latter requirement to focus on regular applications instead of applications sent through ”www.optagelse.dk” outside the application scheme. The dataset contains variables describing the institution the student applies from, the institution they apply to, and the education they apply to. The original data does not show which specific program the student applies to within an education, such as carpenter within VET.

(OA) IV.4 Demographics

We collect demographic information from the ”BEF”, ”UDDA”, and ”IND” registers at Statistics Denmark. Parental linkages in the ”BEF” register allow us to link parents and children together to include information on parental socioeconomic background in the analyses. The list below shows the demographic variable. The dataset contains the information listed below and the years of availability of the underlying data (if the individual has been observed in the labor market) indicated in square brackets. From the basic demographic information, we also calculate parents' highest education level and total income as the sum of parents' income.

1. Age on January 1st within the year. [1980-2017]
2. Gender. [1980-2017]
3. Immigrant status (Danish born citizen; first generation immigrant, second generation immigrant, or missing status). [1980-2016]
4. Home municipality in the first month of the year. [1980-2017]

5. Identifiers for mother and father. [1980-2017]

6. Mother's and father's highest attained education, converted to education levels using the DISCED (Danish International Standardized Edu) (none, lower secondary, VET, High School, Short Professional Bachelor, Medium Length Professional Bachelor, Academic Bachelor, Academic Master, or higher.) [1981-2017]

7. Mother's and father's total income, including all income from salaries, own employment, capital income, and public transfers. [1980-2015]

The demographic data is collected under a larger project specified with Statistics Denmark.[36] As a result, we only observe demographic information for children (and adults) who, at some point, have been employed during the coverage period of the specified project. Table (OA) IV.1 shows the coverage of the demographic dataset. From 2009 to 2015 information on demographics, income, and highest attained education is available for all children in the sample. There is complete coverage for all years from 2009 to 2015. In 2016, the coverage was 97 percent for demographics and highest attained education, and there was no education. For the subgroup of primary school graduates who applied to VET, the coverage is nearly 99 percent for demographic and highest attained education information.

[36]The project at Statistics Denmark has been established as a part of a larger research project in the Innovation, Knowledge, and Economic Dynamics (IKE) research group at Aalborg University. Statistics Denmark provides further information about project guidelines at the following websites: https://www.dst.dk/en/TilSalg/Forskningsservice.

Table (OA) IV.1: Demographic dataset coverage across students in test score data.

	2009	2010	2011	2012	2013	2014	2015	2016
All students								
Total number of observations	88916	92566	94634	94006	93227	92379	91238	92154
Share with demographic info	1	1	1	1	1	1	1	0.97
Share with income info	1	1	1	1	1	1	1	0
Share with attained education info	1	1	1	1	1	1	1	0.97
VET applicants								
Total number of observations	14993	14462	13419	12730	11590	12073	11543	11941
Share with demographic info	1	1	1	1	1	1	1	0.99
Share with income info	1	1	1	1	1	1	1	0
Share with attained education info	1	1	1	1	1	1	1	0.99

Note: The table shows the number of observations that exist in the demographic administrative data (allowing us to observe e.g. gender, age, and mother's and father's identifiers), the income dataset allowing us to observe yearly income (also for linked parents), and the highest attained education level within a given year. The latter datasets are primarily used to identify family demographics such as parental income and highest attained education. The group All Students refer to all students in the main sample consisting of students who have applied to any education (or observably none) and received final test-scores. VET applicants refer to the sub sample of students in the full sample of students applying to any education and having final test-scores from their primary school class.

(OA) IV.5 Defining Consistent Institutions

The 2015 VET reform reduced the share of below-passing students at each VET institution and more so at institutions with higher shares of below-passing students. The main analysis uses the expected drop, which we define as the average share of pre-reform below-passing students applying to each institution, as an instrument for the actual drop. We need consistent institution identifiers to construct and assign the instrument throughout the study period.

However, some VET institution identifiers were inconsistent throughout 2009-2016, which we studied. Between 2012 and 2015, several institutions with multiple locations that had previously been registered under the same institution identifier and name were

given identifiers for each location of the institution despite still belonging to the same collective institution. As a result, some institutions appear as though they are suddenly opening or closing despite remaining open. One example was Roskilde Tekniske Skole, who, until 2014, could be identified by one institution number. In 2015, the institution became registered as three separate administrative units, each with its institution identifier: Roskilde Tekniske Skole at Pulsen, Pulsen 8, and Vilvorde. These splits were partly done at the request of the Ministry of Education for administrative purposes. Because of the administrative register splits, some institutions cannot be persistently identified in the registers. They appear to open and close at different times or see large changes in student bodies.

Figure (OA) IV.3 illustrates the challenge. It shows the institution-year distribution of students applying to each institution, identifying numbers by year and the prior year from 2011 to 2016. Orange dots show institutions with no students the prior year, and purple dots show institutions with no students the following year. The grey band indicates changes in the number of students between positive and negative 50 percent. Green densities on the figure's side illustrate the institution size distribution. The figure shows that a substantial amount of educational institutions appear as though they suddenly opened and closed, and some institutions appear to lose or gain substantial amounts of students suddenly.

We attempt to solve the challenge by merging institutions into consistent institution identifiers using information from the official institution register from the Danish Ministry of Children and Education and Styrelsen For IT og Læring (2022a). The institution register contains historical information on which institutions split into other institutions and which are subdivisions of another institution within a given year. When we observe an institution

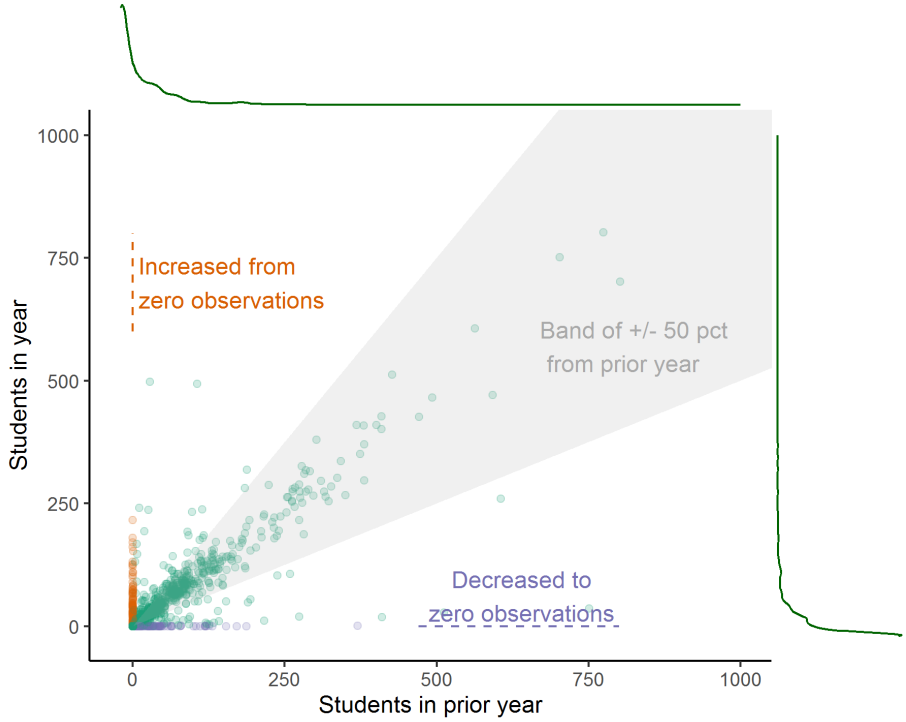


Figure (OA) IV.3: Number of students applying to unique institution identifier in the year and prior year.

Note: The plot shows the number of primary school students applying to a given institution each year and the year prior. Orange dots indicate institutions that received no applications the prior year, and purple dots indicate institutions that received no applications the following year. The grey shaded area indicates a band of ±50% around the prior year's number of students. The green graphs on the right and upper side of the graph show histograms for the opposite axis observations.

split in our administrative data, we attempt to assign one the collective institution identifier throughout.

The approach removes nearly all outliers in the number of applying students. This can be seen in Figure (OA) IV.4, which shows the same distributional plot as Figure (OA) IV.3, but using the updated institution identifiers. There still exist institutions that open and close over time after we perform the merging, the extreme outliers have been removed. After

merging institutions, we observed a total of 111 institutions in the years 2013 and 2014, which we used as the basis for creating our instrument. Table (OA) IV.2 shows that we can assign instrument values for nearly all students and institutions observed in the application data between 2009 and 2016.

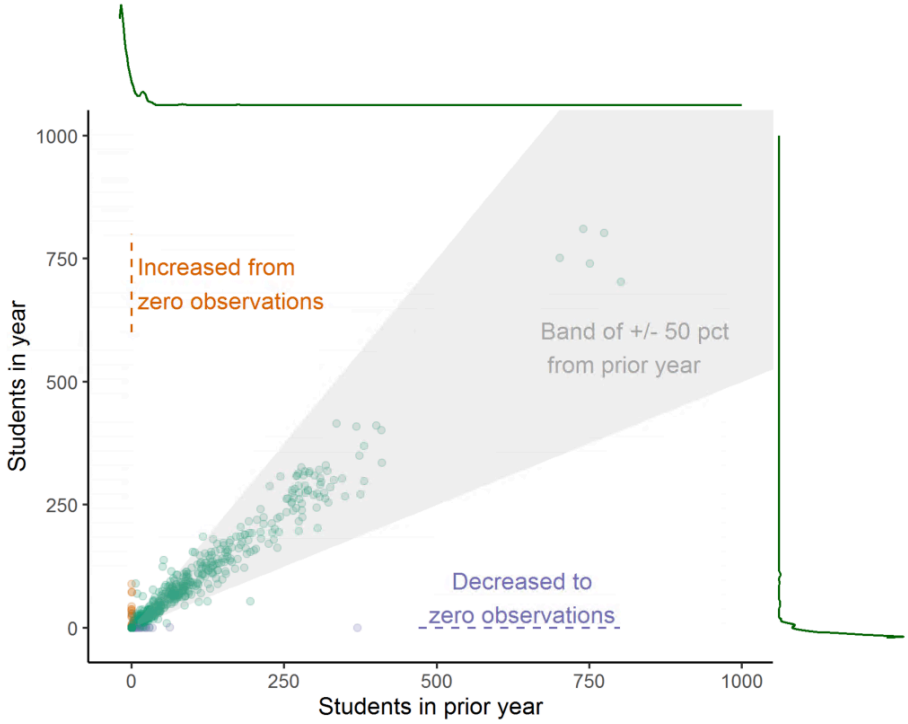


Figure (OA) IV.4: Number of students applying to unique institution identifier in the year and prior year after merging institutions that have been split.

Note: The plot shows the number of primary school students applying to a given institution in each year and the year prior after we have merged institutions, which at some point are split into separate institution identifiers. The figure shows updated numbers from figure (OA) IV.3. Orange dots indicate institutions that received no applications the prior year, and purple dots indicate institutions that received no applications the following year. The gray shaded area indicates a band of ±50% around the prior year's number of students. The green graphs on the right and upper side of the graph show histograms for the opposite axis observations.

Table (OA) IV.2: Students and institutions that can be assigned a potential treatment share based on 2013-2014 applications

	2009	2010	2011	2012	2013	2014	2015	2016
Share of students assigned	0.97	0.97	0.99	1	1	1	1	1
Share of institutions assigned	0.93	0.92	0.96	0.99	1	0.99	0.99	1
Number of VET institutions	103	106	103	101	108	110	104	100

Note: The table shows the share of students and VET institutions that can be assigned a 2013-2014 based treatment share. The treatment shares are taken by averaring the shares of applicants with below-passing minimum GPA in Literathre or Mathematics by institution. This value is then assigned to institutions across years. The first row shows the share of students applying to an institution that can be matched among the 2013-2014 institutions while the second row shows the share of all VET institutions applied to that are matched among the 2013-2014 institutions. The coverage is not complete for 2014 as we only observe 108 institutions in 2013 and 110 in 2014 and only calculate shares for institutions observed in both years.

(OA) V VET dropouts' educational enrollment and attainment

In this section, we use the administrative data described in section (OA) IV to characterize the school enrollment and degree attainment of those students who left VET between 2008 and 2014. We identify VET dropouts as those students who start a VET program and either leave vocational education entirely after one year or are enrolled in another introductory program than the one they initially enrolled in. The sample only contains students who enrolled in VET directly after 9th or 10th-grade primary school between 2008 and 2014, purposely leaving out post-VET-reform cohorts. The outcomes are whether the student is enrolled in some education and whether the student obtains educational qualifications within five years from their initial enrollment. We observe qualifications until 2019, five years after enrollment for the 2014 cohort, and enrollment until 2017, three years after enrollment for the 2014 cohorts.

Our first finding is that 41 percent of students who enter a VET program have dropped out one year later. Table (OA) V.1 shows the share of students by cohort that have dropped out of their VET program after the first school year. This share, calculated from the administrative data, is consistent with the overall dropout rates from the VET programs described in Section (OA) II on the Danish education system. .

Table (OA) V.1: VET entrants' status one year after start

	N	Share
Left program	44215	0.4087
Staid in program	63970	0.5913

Most students who leave the VET programs leave the education system entirely or start

another VET education program after they leave their initial program. Table (OA) V.2 shows educational enrollment by program, if any, for the sample of VET leavers. Of those who drop out, 54 percent are not enrolled in any education in the first year after they drop out, and between 39 and 58 remain outside the education system over the following two to five years. Twenty-seven percent of the dropouts have left for another VET program, and an additional 40 percent are in a VET program two to four years after enrollment. The remaining students are enrolled primarily in general upper secondary programs or increasingly in some tertiary education from the fourth and fifth year after enrollment. The overall picture, however, remains that VET dropouts likely leave the education system or remain at the same education level they initially started.

Table (OA) V.2: VET leavers' education participation

Table 22: VET leavers' education participation

	Year from VET start				
	1	2	3	4	5
VET	0.2761	0.4029	0.3955	0.3855	0.2813
Outside ed.	0.5434	0.3896	0.4299	0.4970	0.5757
High School	0.1697	0.1820	0.1367	0.0459	0.0275
Tertiary	0.0000	0.0012	0.0129	0.0539	0.1012
Other	0.0108	0.0243	0.0250	0.0177	0.0142

The high share of VET leavers and re-enrollers in VET programs among those who drop out is also reflected in the development of degree attainment. Table (OA) V.3 shows the highest degree attained by November 1st for the VET leavers one to five years after initial enrollment. Five years after enrollment, only 10 percent had attained a VET degree, and 16 percent had a general upper secondary degree. In contrast, 71.6 percent had not attained any degree.

Table (OA) V.3: VET leavers' degree attainment

Table 24: VET leavers' degree attainment

	Year from VET start				
	1	2	3	4	5
Lower secondary	0.9974	0.9927	0.9883	0.8901	0.7160
VET	0.0002	0.0015	0.0035	0.0299	0.1039
High School	0.0000	0.0000	0.0009	0.0667	0.1594
Tertiary	0.0000	0.0000	0.0000	0.0000	0.0005
Other	0.0000	0.0001	0.0002	0.0032	0.0071
Not registered	0.0023	0.0056	0.0071	0.0100	0.0130

(OA) VI Robustness checks

In this section, we investigate the robustness of our main findings in Table 2 toward changing the specification of the estimation sample, the peer share criteria, and shifting from a continuous to a binary instrument. The resulting coefficient estimates for enrolling in Main or Introductory VET can be seen in table (OA) VI.1, where the first four columns indicate the dimension we change. The fifth column shows the first-stage F-statistic associated with the estimates. Finally, the last column show the estimated coefficients and their standard errors.

We focus first on changing how we define the peer share from final GPAs to preliminary GPAs. Preliminary grades are strongly associated with the final GPA grades. Still, the distribution is skewed at lower grade points, so fewer students have below-passing preliminary grades. Those who do are likely to be doing particularly poorly in their lower secondary education before their exams. When we use these below-passing preliminary grade student shares, the first-stage F-statistic drops to 494.55. This may reflect that there are fewer students with below-passing preliminary shares and therefore less variation, and that the reform targeted final and not preliminary grades, which should reduce (slightly) the first-stage predictive power. The associated coefficient estimates are inflated to 0.25 for the Introductory program re-enrollment and -0.09 for the Main program enrollment. One interpretation is that the weaker first stage increases the associated estimates mechanically. Another interpretation is that the students who get below-passing preliminary grades have an even stronger peer effect. In contrast, when we define the below-passing share with the final GPAs but use a sample of students who pass their predicted primary school GPAs, we find nearly similar results as in the main estimation. With a binary instrument, we

Table (OA) VI.1: Robustness tests, varying the estimation sample criteria, instrument specification, and peer variable specification

Sample criteria	IV variable	Peers share crit.	F-statistic	Estimate (SE)
Introductory program (month 12)				
Final gpa	Binary	Final gpa	4959.29	0.0905 (0.0905)
Final gpa	Binary	Preliminary gpa	494.55	0.2506 (0.2506)
Final gpa	Continuous	Final gpa	5247.68	0.0573 (0.0573)
Final gpa	Continuous	Preliminary gpa	440.46	0.1622 (0.1622)
Predicted gpa	Binary	Final gpa	4898.76	0.0748 (0.0748)
Predicted gpa	Binary	Preliminary gpa	563.87	0.2053 (0.2053)
Predicted gpa	Continuous	Final gpa	5393.49	0.0442 (0.0442)
Predicted gpa	Continuous	Preliminary gpa	449.66	0.1268 (0.1268)
Main program (month 12)				
Final gpa	Binary	Final gpa	4959.29	-0.0316 (-0.0316)
Final gpa	Binary	Preliminary gpa	494.55	-0.0876 (-0.0876)
Final gpa	Continuous	Final gpa	5247.68	-0.0204 (-0.0204)
Final gpa	Continuous	Preliminary gpa	440.46	-0.0578 (-0.0578)
Predicted gpa	Binary	Final gpa	4898.76	-0.0301 (-0.0301)
Predicted gpa	Binary	Preliminary gpa	563.87	-0.0827 (-0.0827)
Predicted gpa	Continuous	Final gpa	5393.49	-0.022 (-0.022)
Predicted gpa	Continuous	Preliminary gpa	449.66	-0.063 (-0.063)

Note: The table shows coefficients from regressing indicators for participation in the Introductory or Main VET program 12 months after enrollment onto an instrumented share of peers entering VET from lower secondary education with below-passing grades in Mathematics or Danish. The estimation sample consists of individuals entering VET from lower secondary education who have either passed their final exams or would have passed in predicted GPA based on preliminary grades. The predicted GPA is constructed by regressing the final minimum GPA obtained between Mathematics and Danish onto a 4th-order polynomial in the minimum preliminary grades in the two subjects. The instrument is either binary or continuous. The binary instrument takes the value one in years from 2015 if the student enters an institution that had an above-median share of below-passing entering students in 2013-2014, and zero otherwise. The continuous treatment variable takes the value zero before 2015 and the expected share of students screened out of VET in 2015 and 2016 due to reform. The expected share is calculated as the share of 2013-2014 applicants to the institution whose minimum Mathematics or Danish GPA was below passing. The peer share criteria denote whether final exam GPAs or preliminary test scores are used to calculate the share of below-passing peers. The remaining right-hand-side variables in the regressions include the student's own standardized GPA, an indicator for being female, and an indicator for having at least one parent with a tertiary degree. The fixed effect indicators include year, grade level, entered field indicators, and entered institution indicators. They finally include entered institution times continuous year variable interactions. First-stage F-statistics show the heteroskedasticity robust F-statistic for leaving out the instrumental variable in the first-stage regression. Parentheses show heteroskedasticity robust standard errors.

find an estimated effect on Intro program participation of 7.48 percentage points and -0.02 percentage points for the Main program. Using the continuous instrument instead of the binary instrument produces similar but slightly attenuated estimates.

(OA) VII Placebo test

Our identification strategy relies on the reform-induced shift in the share of below-passing students from lower secondary education being exogenous with respect to other factors that affect education enrollment outcomes. In this section, we investigate this exclusion restriction by doing a placebo analysis, where we assign the instrument treatment to the right institution but in a given pre-reform year, dropping all observations from the reform years. For each placebo assignment to a non-reform year, we then calculate the associated robust F-statistic for the first stage and the estimated IV coefficient for the effect of the standardized share of below-passing peers on the education participation of the above-passing students.

We first show the F-statistic and IV-estimates from the placebo regressions in Table (OA) VII.1, where each column corresponds to a combination of the outcome variables, either being in the Introductory or Main program and assignment of treatment to a given year between 2009 and 2014. While we note that the estimated first-stage F-statistics is often above 10, the main finding from these regressions is that when the first stage is stronger, the estimated instrument coefficients go towards zero. When the first-stage relation is weaker, the estimated coefficients tend to increase and may become either positive or negative with seemingly little systematic movement.The reduced form coefficients fluctuate similarly, and are generally statistically insignficant. We view this as indicative that our reform instrument is picking up true reform-induced variation in peer shares and that the estimated effects are attributable to peer changes.

Table (OA) VII.1: Estimated effects on Main and Introductory enrollment using placebo experiment, assigning continuous instrument value to one of years 2009-2014.

	Intro (month 12)						Main (month 12)					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
IV												
Share peers below passing	0.023	-0.178*	-0.293**	-0.001	-0.005	-0.038	-0.030	0.026	0.121	0.028	0.015	0.019
	(0.117)	(0.098)	(0.121)	(0.027)	(0.016)	(0.032)	(0.129)	(0.104)	(0.123)	(0.031)	(0.018)	(0.036)
Num.Obs.	52542	52542	52542	52542	52542	52542	52542	52542	52542	52542	52542	52542
Reduced Form												
Placebo instrument	0.020	0.156*	-0.218**	0.002	-0.027	0.131	-0.026	-0.022	0.090	-0.083	0.089	-0.065
	(0.102)	(0.082)	(0.084)	(0.082)	(0.093)	(0.110)	(0.112)	(0.091)	(0.091)	(0.091)	(0.105)	(0.124)
Num.Obs.	52542	52542	52542	52542	52542	52542	52542	52542	52542	52542	52542	52542
First Stage												
Placebo instrument	0.874***	-0.877***	0.744***	-2.970***	5.821***	-3.463***	0.874***	-0.877***	0.744***	-2.970***	5.821***	-3.463***
	(0.170)	(0.135)	(0.124)	(0.145)	(0.172)	(0.210)	(0.170)	(0.135)	(0.124)	(0.145)	(0.172)	(0.210)
Num.Obs.	52542	52542	52542	52542	52542	52542	52542	52542	52542	52542	52542	52542
Placebo year	2009	2010	2011	2012	2013	2014	2009	2010	2011	2012	2013	2014
Individual controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Inst. X year (cont.) FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Grade level FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
VET Field FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
F-stat (1st stage)	26.58	42.47	36.26	422.45	1143.56	273.01	26.58	42.47	36.26	422.45	1143.56	273.01

Note: The table shows 2SLS, Reduced Form, and First Stage coefficients from placebo experiments, where we regress Introductory or Main program participation 12 months after enrollment on the share of students entering VET from lower secondary education who have not passed either or both of their Mathematics and Danish final exams, instrumented with placebo instruments. The estimation sample consists of 2009-2014 cohort student entering VET from lower secondary education who passed their Mathematics and Danish final exams. The placebo instruments take the value of the expected share of entering students that would be screened out at the institution if the reform had happened in the placebo year, and zero in all other years. The expected share is calculated as the share of 2013-2014 lower secondary VET applicants to the institution whose minimum Mathematics or Danish gpa was below passing. The additional control variables the student's own standardized GPA, an indicator for being female, and an indicator for having at least one parent with a tertiary degree. The fixed effect indicators include year, grade level, entered field indicators, and entered institution indicators. They finally include entered institution times continuous year variable interactions. First stage F-statistics show the heteroskedasticity robust F-statistic for leaving out the instrumental variable. Parentheses show heteroskedasticity robust standard errors. Stars indicate levels of statistical significance: *** 1 percent level; ** 5 percent level; * 10 percent level.

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