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The impact of prior education on student success in higher education: how do different school types influence success in different fields of study?

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ABSTRACT

The course of an individual's education is shaped by a series of pivotal decisions. Each of these decisions has the potential to influence educational pathways and success. This study examines the impact of upper secondary school type on success in higher education in Austria. Austria offers a high degree of diversification in its educational system, with a range of academic and vocational pathways available from the age of 14. I introduce the concept of disciplinary counterparts which describes types of high schools and fields of study that share the same or a similar field of education. Based on administrative data of students, separate Cox proportional hazards models for 16 fields of study are fitted. The findings indicate that no school type has a consistently higher graduation probability across all fields of study. Students from business vocational high schools (VHS) and technical VHS have a higher graduation probability in fields of study that are considered disciplinary counterparts than students from other types of VHS and academic high schools. This study emphasises the significance of prior education and the necessity of providing support structures for students who change fields between the upper secondary and tertiary level to enhance success for all students.

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Event history methods; fields of study; prior education; student success; vocational education

Introduction

In almost all countries, at some point in their educational history, students are sorted into different educational tracks (Triventi, Barone, and Facchini 2021). The impact of school tracking on efficiency and inequality is a long-standing debate among scholars, with contrasting theoretical arguments and ambiguous empirical findings (Terrin and Triventi 2023). When and how tracking takes place varies considerably across countries (Blossfeld et al. 2016). Simplified, at the upper secondary level in many European countries, it boils down to an academic track with general education versus a vocational track (European Commission 2023; Ozer and Perc 2020).

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Austria has a high degree of diversification in its education system and is an interesting case because the popular school type of vocational high schools promises to strike a balance between general and vocational education. Like graduates of academic high schools, graduates of vocational high schools can commence studies at all types of higher education institutions and in all fields of study.[1] Inherent in the system is the promise to adolescents and their parents that after vocational high school, all paths into and through higher education are open (as reflected in Federal Ministry of Education, Science and Research 2022). This system's inherent promise motivated this study, where I examine the impact of different types of academic and vocational high schools on success in Austrian higher education.

Another motivation of this study is reflected by previous research showing that the type of upper secondary school influences the probability of completing or dropping out of higher education (Clerici, Giraldo, and Meggiolaro 2015; Heublein et al. 2017). However, it is difficult to synthesise the effects of upper secondary school type on success in higher education across Europe due to the heterogeneity of national education systems (Larsen et al. 2013). There is a lack of systematic analysis of the impact of different vocational and academic high schools on students' success in different fields of study.

These research gaps led to the following overarching research question: *What is the impact of school type on student success in Austrian higher education?* Based on theoretical considerations such as domain-specific prior knowledge (Fischer et al. 2020; Sadler and Tai 2007; Simonsmeier et al. 2022), the key assumption is that graduates of a certain school type have a higher chance of graduating in a field of study that is a 'disciplinary counterpart' than graduates of other school types. School types and fields of study are considered disciplinary counterparts if they share the same or a similar field of education. The research question will be explored in three steps. The first step is of explorative and descriptive character and addresses the composition of fields of study by school type. This provides information on whether school types are evenly distributed across the 16 selected fields of study, whether there are clusters of students associated with disciplinary proximity, or whether there are other peculiarities. In the second step, the graduation rates provide a descriptive overview of the variability of graduation rates across school types and fields of study. The third and final step of the analysis is the estimation of the graduation probabilities of school types within each field of study, while controlling for other influencing factors. Therefore, Cox proportional hazards models are fitted separately for the 16 selected fields of study. The analysis is based on administrative data of students from universities and universities of applied sciences in Austria.

This analysis is relevant on three levels: first, it has implications for 14-year-olds and their parents when choosing a high school, as to whether they can rely on the system's inherent promise that all paths into and through higher education are possible and achievable. Second, it may provide new insights for higher education institutions aiming at improving student success, for example by considering student support measures related to prior education. Third, it can provide a new perspective for the discussion on school tracking by focusing on vocational high schools and their impact on subsequent educational pathways.

Review of relevant literature

Student success is a complex and multifactorial phenomenon (Behr et al. 2020; Kuh et al. 2007). There is no consistent definition of student success in research.

Frequently, the term is used to refer to graduation or the absence of dropout (Kuh et al. 2007), but there are also analyses of student success that focus on grades (Richardson, Abraham, and Bond 2012) or study duration until graduation (DesJardins 2003). The factors that impact student success can be grouped into three categories. Individual-level factors include, for example, gender, age, and family background, such as the level of education attained by parents and migration background (Behr et al. 2020; Heublein et al. 2017). The second group of factors are those at the institutional level, including study conditions (Chen 2012; Marczuk 2023). Finally, external factors include, for example, employment during studying (Lessky and Unger 2023; Riggert et al. 2006). For this study, the influence of prior knowledge, prior education, and fields of study are of particular importance and are therefore discussed in more detail in the following sections.

Prior knowledge and prior education

One area of individual factors is the prerequisites of new students, such as prior knowledge and prior education. These factors can influence educational pathways, ranging from the initial decision to study to the decision whether to continue studying or drop out of higher education (Crisp, Potter, and Taggart 2022; Heublein et al. 2017; Terrin and Triventi 2023). The impact of prior school type is related to differences in curricula: Academically oriented schools provide a comprehensive general education and preparation for university, whereas vocational schools offer a more vocationally oriented curriculum (Clerici, Giraldo, and Meggiolaro 2015; Triventi, Barone, and Facchini 2021).

The model of prior knowledge proposed by Hailikari, Nevgi, and Komulainen (2008) distinguishes between two forms: declarative knowledge is the knowledge of facts and meaning, and procedural knowledge refers to the integration and application of knowledge. In accordance with the model of Hailikari, Nevgi, and Komulainen (2008), Binder, Schmiemann, and Theyssen (2019) examined the role of prior knowledge in the acquisition of knowledge among university students in biology and physics. Their analysis revealed that students who were low achievers in high school started with a lower level of prior knowledge than their high achieving counterparts. Furthermore, high school low achievers were not able to reach the level of prior knowledge of high school high achievers within the first year of study (Binder, Schmiemann, and Theyssen 2019). A comprehensive meta-analysis conducted by Simonsmeier et al. (2022) indicates that prior knowledge is a good predictor of later performance. However, the impact of prior knowledge on learning (i.e. knowledge gain) remains unclear (Simonsmeier et al. 2022).

Prior education or the type of upper secondary school can influence the success of students in higher education (Clerici, Giraldo, and Meggiolaro 2015; Heublein et al. 2017). Nevertheless, it is challenging to synthesise these effects, as national education systems are difficult to compare across Europe (Larsen et al. 2013). In Austria, the graduation rates of students from different school types and access pathways vary considerably. In bachelor's programmes at Austrian universities, the graduation rates of students with different prior education range from 33% to 51%, while at Austrian universities of applied sciences, they vary between 72% and 93% (Schubert et al. 2020).

The role of fields of study

The four main groups of academic disciplines comprise of natural sciences (hard-pure), humanities and pure social sciences (soft-pure), technology (hard-applied), and applied social sciences (soft-applied; Becher 1994). These disciplines exhibit differences not only in the nature of knowledge, but also in their culture (Becher 1994). Furthermore, there seems to be a hierarchy of fields of study (Iannelli, Gamoran, and Paterson 2018). For example, according to the perceptions of UK students, biology is perceived as the easiest STEM degree (Wong et al. 2023).

A growing number of research studies acknowledge the diversity of disciplines and the value of separate statistical models for each discipline in order to understand the factors influencing student success (Clerici, Giraldo, and Meggiolaro 2015; Posch, Thaler, and Lessky 2021). The level of success rates can vary between different fields of study, but there is also evidence that individual factors can have heterogeneous effects in different fields. For instance, in certain academic disciplines, women are more likely to graduate than men, whereas in other disciplines, men are more successful (Posch, Thaler, and Lessky 2021).

Domain-specific impacts of prior knowledge and prior education

The positive impact of prior knowledge on later performance is greater when the prior knowledge is drawn from the same knowledge domain (Simonsmeier et al. 2022). A study by Sadler and Tai (2007) demonstrated that college students in biology, chemistry, and physics have better grades the more courses they took in that particular subject in high school. In addition, high school mathematics courses have a positive effect on grades in all three subjects at college level (Sadler and Tai 2007). Fischer et al. (2020) investigated the effects of prior knowledge on the intention to change the field of study or withdraw from higher education. Their study revealed that students with lower levels of subject knowledge acquired in school are more likely to develop an intention to change courses or drop out. This factor is of particular relevance in STEM fields but appears to be less influential in social sciences (Fischer et al. 2020).

There is a paucity of research investigating the impact of vocational high schools on student success in higher education. A notable exception is the study by Farías and Sevilla (2015), which examined the impact of vocational upper secondary schools on vocational education at the tertiary level in Chile. The findings indicate that students from vocational upper secondary schools who continued in the same field perform better in vocational education at the tertiary level than students from vocational upper secondary schools who changed their field, as well as those who have attended academic upper secondary schools (Farías and Sevilla 2015). It is unclear whether the findings from Chile can be generalised to other countries. The current study addresses this research gap by analysing the effects of vocational high schools on student success in two types of higher education institutions in Austria.

Background and hypotheses

Context of this study: the Austrian education system

In Austria, the first tracking takes place at the age of ten for lower secondary school and is based on ability. The second tracking occurs at the age of 14 for upper secondary

school and is based on ability and vocational interests. With the features of early tracking and a differentiated system at the upper secondary level, the Austrian education system shares some similarities with that of Germany and Switzerland. However, there are also some specialities, particularly regarding the types of upper secondary schools. Austria has two main types of upper secondary school that provide access to higher education: academic high schools (AHS) and vocational high schools (VHS, in German 'BHS'). Upon graduation from either school type, students receive a high school diploma ('Matura') that serves as a general university entrance qualification. Alternative options for vocational education from the age of 14 include schools of intermediate vocational education or pre-vocational schools followed by an apprenticeship. These students can access higher education via alternative access routes, such as the university entrance qualification examination. Alternative access routes are not covered in this paper.

Within AHS, there are two main types: the 'Gymnasium' which focuses on humanities and languages, and the 'Realgymnasium' which focuses on natural sciences and mathematics. Both types of AHS start at the age of ten and last eight years. Additionally, there are specialised forms of AHS, some of which commence at the age of 14 and last four years. These also have different focuses, such as economics or musical-creative educational content (Federal Ministry of Education, Science and Research 2022). Graduates from all forms of AHS are typically 18 years old.

In contrast to AHS, which provide in-depth general education, VHS additionally provide a specific vocational education. VHS commence at the age of 14 and have a duration of five years, with VHS graduates typically being 19 years old. There are several types of VHS: business high schools ('HAK') specialise in business, accounting, and finance. Technical high schools ('HTL') focus on engineering or ICT (information and communications technology). Pedagogical high schools offer training in kindergarten pedagogy ('BAfEP') or social pedagogy ('BASOP'). Other types of VHS include, for example, tourism, fashion, and agriculture.

The composition of upper secondary schools differs according to social class and gender. Parents of students at high schools, particularly those at academic high schools, tend to have higher levels of education than those at other school types (Wimmer and Oberwimmer 2021). Technical high schools, which have a high proportion of male students, and pedagogical high schools, which have a high proportion of female students, are particularly notable for their gender imbalance (Statistik Austria 2023).

Following the completion of high school, 87% of AHS graduates and, depending on the type of VHS, between 45% and 60% of VHS graduates transition to higher education within three years (Statistik Austria 2023). Those who do not transition to higher education typically enter the labour market, particularly those who have attended a VHS.

The Austrian higher education system consists of public universities (henceforth: universities), which represent the largest sector, and universities of applied sciences (UAS). Additionally, there are 'university colleges of teacher education' and private universities, which are small sectors and not covered in this study.

Access to universities is generally open to all students holding a high school diploma. Some study programmes at universities have introduced admission procedures, but only a few of these are highly competitive (Haag et al. 2020). In contrast, Austrian UAS offer a

fixed number of study places and have admission procedures in place. The tuition fees in both sectors are relatively low, with the maximum fee (for EU students) being 727 EUR per academic year.

Studying at UAS is characterised by certain structures with a 'classroom setting', where one cohort usually stays together until graduation. Austrian UAS offer two forms of curriculum organisation: full-time and extra-occupational. In extra-occupational programmes, classes are held in the evening or on weekends, however, the study duration for a bachelor's degree is three years, which is the same as for full-time programmes. In contrast, at universities, the curriculum is characterised by a high degree of flexibility. For instance, there is no minimum requirement for credit points to be achieved within an academic year, nor is there a maximum duration of enrolment. Consequently, long study durations are prevalent among students at Austrian universities (Schubert et al. 2020). Furthermore, it is not uncommon for Austrian students to be enrolled in more than one study programme, particularly those attending universities. For the purposes of the current study, this implies that students may be included more than once if they are enrolled in more than one field of study.

Conceptualising 'disciplinary counterparts' and hypotheses

The aim of this study is to understand the impact of prior education on student success in Austrian higher education, with a special focus on vocational high schools. The positive impact of domain-specific prior knowledge on subsequent educational success (Fischer et al. 2020; Sadler and Tai 2007; Simonsmeier et al. 2022) suggests that in a certain field of study, students from schools with a disciplinary proximity, may have a higher probability of graduating. Therefore, a key concept of this study is 'disciplinary counterparts' of vocational high schools and fields of study (Table 1). The degree of disciplinary proximity between vocational high school and field of study is determined based on official descriptions of school types from the Federal Ministry of Education, Science and Research (2022), timetables of different school types, and three short interviews with national experts. Teacher training at universities prepares teachers for secondary schools and includes pedagogy and two subjects. Consequently, one part of the curriculum has a degree of proximity, while the other two parts do not. Teacher training for primary education takes place at 'university colleges of teacher education', which are not covered in this study due to data availability.

The assumptions about which students are more likely to succeed, vary according to whether there are disciplinary counterparts at the high school level.

Table 1. Disciplinary counterparts of vocational high schools and fields of study.

Vocational high school	Field of study	Degree of proximity
Business high school (VHSbus)	Business	high
	Economics	intermediate
Technical high school (VHStec)	Information and communications technology (ICT)	high
	Engineering	high
	Architecture	intermediate
Pedagogical high school (VHSped)	Education science	high
	Teacher training (at universities)	intermediate

Hypothesis for fields of study with counterparts in vocational high schools: *[H1] Students from vocational high schools with a high or intermediate degree of disciplinary proximity have a higher graduation probability compared to students of other types of academic and vocational high schools.* In cases with an intermediate degree of proximity, the effects are expected to be less pronounced than in cases with a high degree of proximity.

Hypotheses for fields of study without a counterpart in vocational high schools: *[H2] Students from academic high schools have a higher graduation probability compared to vocational high schools.* This hypothesis is based on the assumption that, in these cases, domain-specific prior knowledge does not play a major role. Instead, it is expected that general knowledge and academic preparedness have a higher impact (Clerici, Giraldo, and Meggiolaro 2015), and these are the core competencies of academic high schools (Federal Ministry of Education, Science and Research 2022). A final set of hypotheses compares the two main types of academic high schools, those focusing on humanities (AHShum) and those focusing on natural sciences (AHSnat), and is also based on disciplinary proximity: *[H3a] Within academic high schools, academic high schools with a focus on humanities have a higher graduation probability in humanities and languages than academic high schools with a focus on natural sciences. [H3b] Within academic high schools, academic high schools with a focus on natural sciences have a higher graduation probability in mathematics and natural sciences than academic high schools with a focus on humanities.*

Data and methodology

Data

The data source for the analysis is administrative data and consists of several different data sets, which are accessed via the Austrian Micro Data Center (Fuchs et al. 2024). Firstly, university statistics provide data on students and graduates at universities and UAS. Additionally, the data set encompasses information from the compulsory survey on the highest level of education attained by parents, which all students are required to complete at the commencement of their studies. Secondly, school statistics provide data on high school graduates and the school type that they attended. Thirdly, data on register-based labour market careers provides information on the employment of students. Furthermore, this data source includes information on the country of birth, and it can be linked with the parents of students. The three data sources can be joined within and across the data sources via anonymised person identifiers.

The population of interest comprises of bachelor programmes at public universities and UAS for cohorts beginning in the academic years 2011/12–2015/16. The selected cohorts were chosen to ensure a sufficiently long observation period (until 2021/22), given that a significant proportion of bachelor's graduates take considerably longer than three years to complete their studies (Schubert et al. 2020). For the analysis, students who completed high school in Austria were selected. Students who accessed higher education via alternative access routes are excluded, as they are not covered by the research question and the hypotheses. Furthermore, the analysis is limited to students who are younger than 25 years at the commencement of their studies, due to data availability constraints. The total number of cases for the 16 fields of study is 134.318 (for case numbers in each field of study, see Table A1 in the appendix).

One advantage of administrative data is that it eliminates the potential for different types of response bias that can occur in survey data. However, one limitation of administrative data is the predetermined selection of variables. For example, a measure for students' competencies and information on students' perspectives, such as their motives and motivations, are not available for the analysis. Nevertheless, the newly created possibility of linking school and higher education data at the micro level allows for novel analysis, such as an integrated perspective on previous and subsequent educational pathways and success.

Modelling strategy

In the analysis of educational outcomes with temporal aspects, event history methods are a valuable tool (DesJardins 2003). The Cox proportional hazards (PH) model allows for the consideration of not only the state at the end of an observation period, but also the duration until the event occurs. The Cox PH model can be written as follows:

$$\lambda(t) = \lambda_0(t)e^{\beta_1 x_1 + \beta_2 x_2 + \ldots}$$

where $\lambda_0(t)$ denotes the baseline hazard function and $e^{\sum \beta_i X_i}$ contains effect sizes and the covariates. The statistical analyses were performed using R (version 4.1.3; R Core Team 2022) and the survival package (Therneau 2023). In the Cox PH model, time is treated as a continuous variable. Carreira and Lopes (2021) argue that discrete time models are more suitable for educational data, given that the duration until event is often only available in aggregated time intervals. For my analysis, robustness checks have shown that the differences in the results of event history models fitted for a discrete time setting and the results of the Cox PH model are barely discernible (see Figure A1 in the appendix).

The definition of fields of study is as detailed as possible, while aiming for a sufficient number of cases, given that students from certain school types are underrepresented in some fields of study. In most cases, this aligns with the narrow field of ISCED-F 2013 (UNESCO 2014). For the analysis, fields of study with disciplinary counterparts at VHS, as addressed by hypothesis H1, are of primary interest. Therefore, for example, economics is analysed separately from other social sciences. Furthermore, fields of study without disciplinary counterparts in VHS but are addressed by hypotheses H3a and H3b are selected. All fields of study covered by hypotheses H3a and H3b are also covered by hypothesis H2. Additionally, social sciences are selected as an example without a school type with disciplinary proximity. Social sciences are covered by hypothesis H2. Interdisciplinary fields of study and fields of study with small case numbers are excluded from the analysis. Fields of study where the main programme is at diploma rather than bachelor level (e.g. medicine and law), are therefore also not covered in this analysis. Furthermore, universities and UAS are modelled separately, as the typical study progress varies hugely between these two sectors (Schubert et al. 2020).

The school type is coded as a variable with seven categories, three types of AHS (humanities, natural sciences, and other) and four types of VHS (business, technical, pedagogical, and other). The reference category for this variable depends on the field of study and the corresponding hypothesis. For each field of study, the school type that is expected to have the highest graduation probability is defined as the reference category in the models (see Table 1 and hypotheses). For social sciences, there is no straightforward

option as to which school type is the most appropriate reference category. However, hypothesis H2 suggests that it is useful to consider an academic high school as the reference category. Therefore, academic high schools with a focus on humanities are set as the reference category.

For each field of study, a separate model is fitted with an adjusted reference category for school type. Here are two examples, business (B), where business high schools (VHSbus) are the reference category, and engineering (E), where technical high schools (VHStec) are the reference category.

$$\lambda^{B}(t) = \lambda_0^{B}(t)\, e^{\beta_1^{B}\,\mathrm{AHShum} + \beta_2^{B}\,\mathrm{AHSnat} + \beta_3^{B}\,\mathrm{AHSother} + \beta_4^{B}\,\mathrm{VHStec} + \beta_5^{B}\,\mathrm{VHSped} + \beta_6^{B}\,\mathrm{VHSother} + \sum \beta_j^{B} X_j}$$

$$\lambda^{E}(t) = \lambda_0^{E}(t)\, e^{\beta_1^{E}\,\mathrm{AHShum} + \beta_2^{E}\,\mathrm{AHSnat} + \beta_3^{E}\,\mathrm{AHSother} + \beta_4^{E}\,\mathrm{VHSbus} + \beta_5^{E}\,\mathrm{VHSped} + \beta_6^{E}\,\mathrm{VHSother} + \sum \beta_j^{E} X_j}$$

Note that in the first example, there is no effect size β for VHSbus as this is the reference category. Accordingly, in the second example, there is no β for VHStec. In both cases, $\sum \beta_j^{B} X_j$ and $\sum \beta_j^{E} X_j$ contain the effect sizes of the control variables.

The following control variables are included in the models: sex (female, male); age at the commencement of the study programme; highest education of parents (high, mid, low); a dichotomous index of first language and migration background (German, non-German); employment status in the first semester (none, marginally employed, part-time, full-time, (self-)employed with extent unknown); previously enrolled in other programme (no, yes), other programme enrolled in the first semester (no, yes); start in winter semester vs. summer semester (only for universities); programme design full-time vs. extra-occupational (only for UAS); and cohort (2015/16, 2014/15, 2013/14, 2012/13, 2011/12).

Findings

The findings are presented in three sections. The first section addresses the composition of fields of study by school type. The second section provides insight into the variability of graduation rates across school types and fields of study. The third section tests the hypotheses and presents the models, which show the differences in graduation probabilities between school types within each field of study, while controlling for other variables.

Composition of fields of study by school type

The selected fields of study are composed of varying proportions of the seven school types (Figure 1). In business and economics, students from business VHS are the most represented making up approximately 30% of students in the first semester in these fields of study. In engineering and ICT, students from technical VHS represent the largest share and constitute up to half of the student body. Conversely, in architecture, where technical VHS are also considered the disciplinary counterpart, this school type does not dominate that field of study. Technical VHS have a higher proportion (18%) compared to non-technical fields; however, all three types of AHS have higher proportions in architecture (20% or higher).

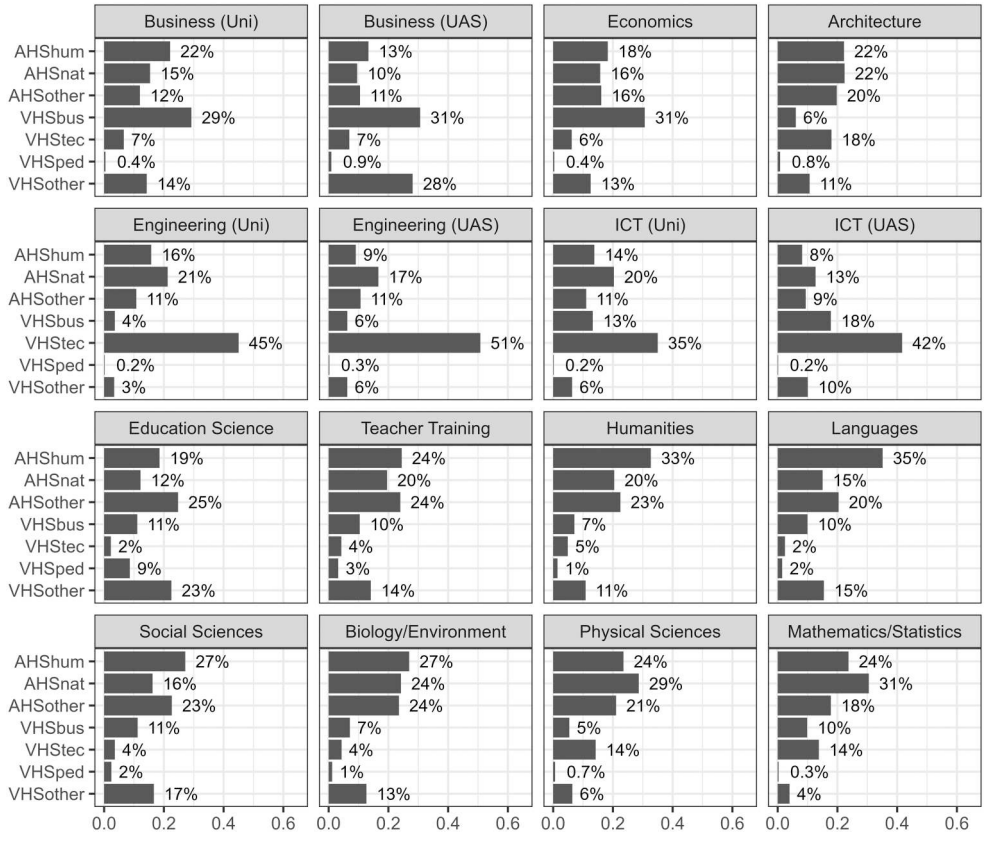

Figure 1. Proportion of school types in 16 fields of study in the first semester.

Notes: Fields of study at universities, if not stated otherwise. The percentages add up to 100% within each field of study. Distribution across all selected fields of study: 22% AHShum, 18% AHSnat, 17% AHSother, 13% VHSbus, 15% VHStec, 1.4% VHSped, 13% VHSother.

In all fields of study, students from pedagogical VHS represent a relatively small proportion, as there are fewer graduates from this school type than from other school types. Compared to other fields of study, pedagogical VHS are overrepresented in education sciences (9%) and, to a lesser extent, in teacher training (3%). In economics, ICT (at universities and UAS), as well as mathematics and statistics, the number of students from pedagogical VHS is particularly small ($n \leq 12$). Therefore, they are excluded from the second and third steps of the analysis.

To summarise, in fields of study with a high degree of disciplinary proximity to a specific type of VHS, there are notable accumulations of students from that particular school type. In fields of study with an intermediate degree of disciplinary proximity to a specific type of VHS, this type has a higher share compared to other fields, but in the case of pedagogical and technical VHS, to a lesser extent than in fields with a high degree of proximity.

A comparison of AHS with a focus on humanities and AHS with a focus on natural sciences reveals that the former has higher shares in humanities and languages, whereas the latter has higher shares in mathematics and statistics, and physical sciences.

In these four fields of study, the AHS-type with closer disciplinary proximity exhibits a higher proportion than the other AHS-type. However, in biology, despite its classification as natural sciences, the proportion of AHS with a focus on natural sciences is not higher (24%) than that of AHS with a focus on humanities (27%).

Although there are discernible accumulations of school types in fields of study that have a disciplinary proximity, there are also students who change their field of education between the upper secondary and tertiary levels. The subsequent sections address the follow-up question of how successful students from different school types are in the different fields of study.

Differences of graduation rates across and within fields of study

The following analysis provides an overview of graduation rates for each school type in the selected fields of study (Figure 2). The reported graduation rate is the proportion of students who successfully graduated in the same field of study within the observation period, which is at least 14 semesters. This is more than twice the minimum duration of a bachelor's programme. The difference to 100% represents students who either transferred to another field of study, dropped out of higher education, or are still enrolled.

There is a considerable variation in graduation rates across fields of study. In general, graduation rates at UAS are higher than at universities. In some fields of study, only a small proportion of students complete their studies successfully, particularly in the humanities. Furthermore, within fields of study, there are notable variations in graduation rates between different school types. For example, in languages, mathematics and statistics, ICT, and engineering at universities, the maximum graduation rate of the seven school types is more than twice as high as the minimum graduation rate of the seven school types. Conversely, the disparity between school types in business at UAS is relatively minor.

In all selected fields of study, the school type that represents the disciplinary counterpart or has disciplinary proximity has the highest or second-highest graduation rate. However, students not only differ in their prior education but also in other characteristics such as their sex or social background. It is therefore necessary to control for other influencing factors when examining the impact of school type on student success.

Multivariate models

The final section of the analysis addresses the question of whether there are any differences in graduation probabilities between school types in each field of study compared to the reference school type, while controlling for other factors. A Cox PH model was fitted for each field of study, with the reference category adjusted to align with the formulated hypotheses. The reported effects are the exponents of the coefficients, and thus, the difference to one can be interpreted as a percentage. If the exponentiated coefficient is less than one, this group has a lower graduation probability than the reference category. Conversely, an exponentiated coefficient greater than one indicates a higher graduation probability than the reference category (Figure 3).

In business at universities and UAS, as well as in economics, except for one category, all school types have a significantly lower graduation probability than business VHS (p

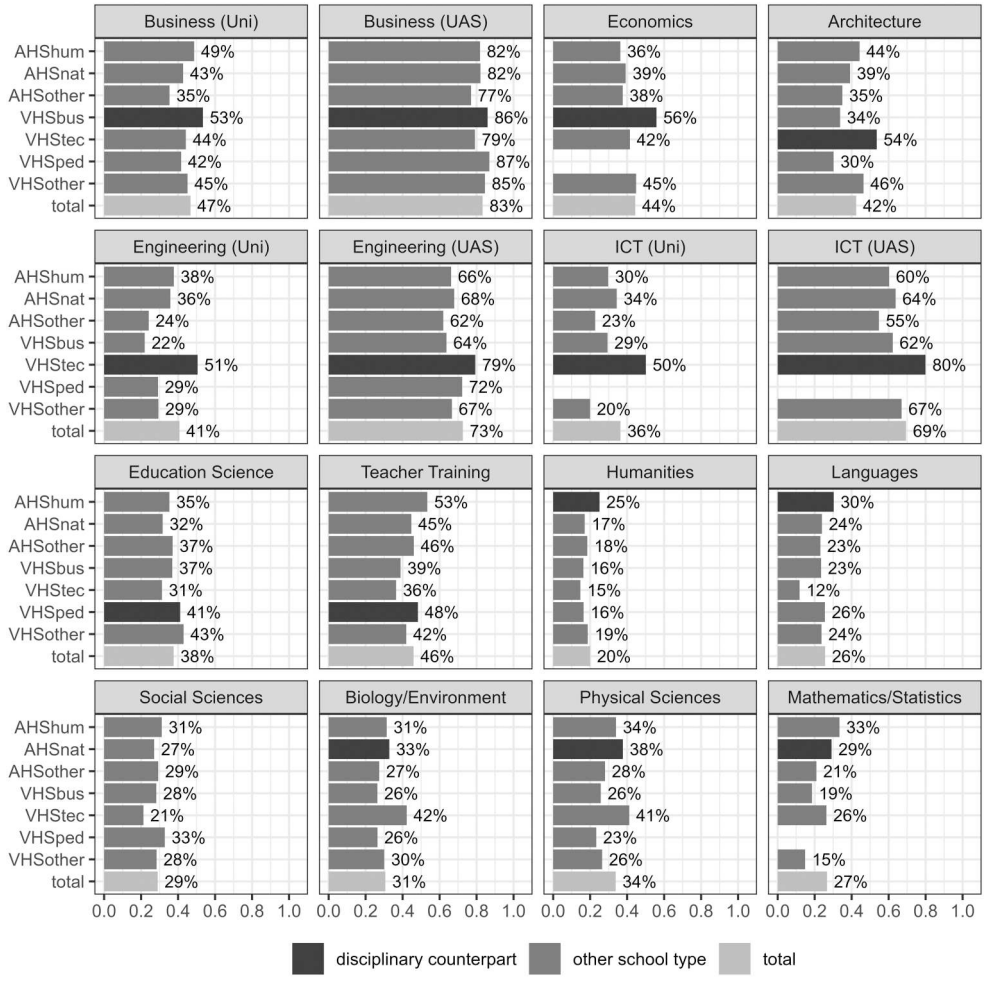

Figure 2. Graduation rates of school types in 16 fields of study.
Note: Fields of study at universities, if not stated otherwise.

< .05). For example, in business at universities, the exponentiated coefficient of AHS with a focus on humanities is 0.68, therefore, their graduation probability is 32% lower than the graduation probability of business VHS, when other influencing factors such as sex, age, and social background are controlled for. The exception is pedagogical VHS. At UAS, their graduation probability is nearly identical to that of business VHS. At universities, the estimated probability of graduating from business is lower for pedagogical VHS. However, this effect is not statistically significant due to the relatively wide confidence interval, which is a consequence of the small number of cases.

In all fields of study where technical VHS represent the disciplinary counterpart, all other school types have a noticeably lower graduation probability (about 35% to 65% lower). In engineering at UAS, the effect of pedagogical VHS is not statistically significant, which is again associated with a small case number and therefore a large confidence interval.

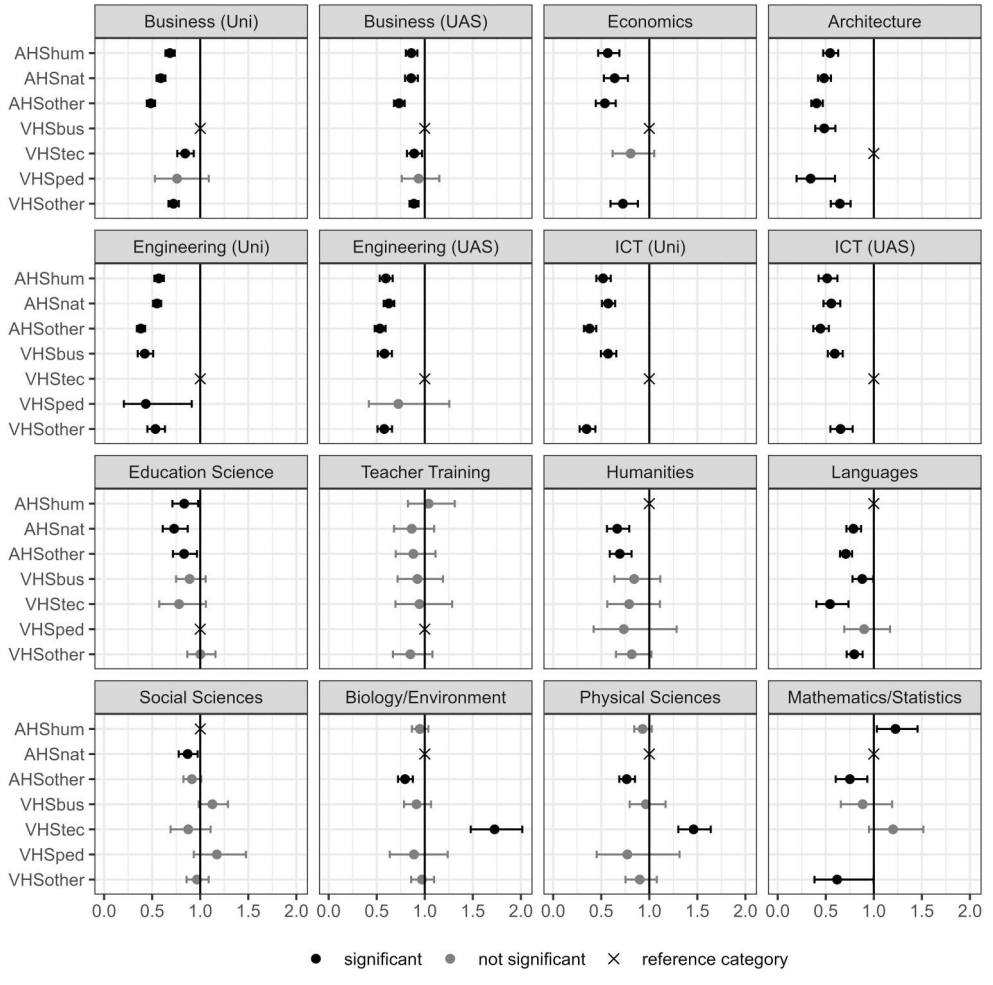

Figure 3. Cox PH models: estimated exponentiated coefficients for graduation of school types in 16 fields of study.

Notes: Fields of study at universities, if not stated otherwise. Significance: $p < .05$. For further details see Table A1 in the appendix.

In education sciences, most school types have a lower graduation probability compared to pedagogical VHS. However, only three of the effects are statistically significant ($p < .05$). In teacher training, there are no significant differences between the various school types and pedagogical VHS.

For fields of study that do not have a disciplinary counterpart in VHS, there is no clear indication that all types of AHS have a higher graduation probability than all types of VHS. Instead, it depends on the specific type of AHS as well as the specific type of VHS.

When comparing AHS with a focus on humanities and AHS with a focus on natural sciences, for humanities and languages, the probability of graduation is higher for AHS with a focus on humanities. However, for natural sciences, there is no advantage of AHS with a focus on natural sciences. In biology and physical sciences, there are no significant differences between the two AHS types. Surprisingly, in mathematics and statistics, AHS

with a focus on humanities exhibit a significantly higher graduation probability than AHS with a focus on natural sciences. Furthermore, technical VHS have a higher graduation probability than AHS with a focus on natural sciences in all three fields within the natural sciences, although the effect is not statistically significant in mathematics and statistics.

Discussion and conclusion

As students in many countries have to navigate through different educational options at the upper secondary level, it is crucial to comprehend the impact of these educational choices on their success in higher education. Previous research has shown that the prior school type has an impact on students' success in higher education, but for Europe, these results are hard to synthesise because of the heterogeneity of education systems (Larsen et al. 2013). This study analysed the case of Austria, where vocational high schools (VHS) are a popular school type at the upper secondary level. These schools provide both general education and vocational training, and their graduates are eligible to enter all fields of study and all types of higher education institutions, just as graduates of academic high schools (AHS). The importance of domain-specific prior knowledge (Fischer et al. 2020; Sadler and Tai 2007; Simonsmeier et al. 2022) led to the assumption that in a specific field of study, students from a high school that is considered a disciplinary counterpart have a higher graduation probability than students from other school types.

The first step of the analysis revealed that in the selected fields of study, there are accumulations of students from school types that are disciplinary counterparts, but there are also students who opted to commence their studies in other fields of study. Thereafter, and in accordance with previous research, the second and third steps of the analysis demonstrated that there are substantial differences across fields of study (Clerici, Giraldo, and Meggiolaro 2015; Posch, Thaler, and Lessky 2021) and that upper secondary school type affects student success in higher education (Clerici, Giraldo, and Meggiolaro 2015; Heublein et al. 2017).

More specifically, no school type, whether AHS or VHS, has the highest graduation rate across all 16 selected fields of study. Instead, the probability of graduation varies considerably depending on the field of study and the school type. In business and economics, graduates of business VHS have the highest probability of graduating compared to all other types of VHS and AHS. Similarly, in ICT, engineering, and architecture, those who attended a technical VHS have the highest graduation probability. For these fields, the first hypothesis [H1], which postulated that graduates of VHS that are disciplinary counterparts, would be the most successful in the corresponding field of study, can be confirmed.

Architecture, where technical VHS are considered a disciplinary counterpart with an intermediate degree of proximity, is an interesting case. The proportion of students from technical VHS is not the highest in this field; instead, there are more students from each of the three AHS types. Consequently, the composition of that field of study presents a distinct picture in comparison to engineering and ICT, which are considered to have a high degree of proximity to technical VHS. In these fields, technical VHS constitute up to half of the student body. However, when graduation probabilities are considered,

architecture exhibits comparable effect sizes to engineering and ICT, with technical VHS demonstrating the highest graduation probabilities. These findings may indicate that students from AHS may underestimate the technical knowledge that universities consider prerequisites for architecture.

In the case of pedagogical VHS, the evidence is less clear than in the case of business VHS and technical VHS. In education sciences, students of pedagogical VHS have a higher graduation probability than the majority of other school types, but only half of the effects are statistically significant. Consequently, although the hypothesis cannot be fully statistically confirmed, the findings support the direction of the hypothesis. Teacher training is considered to be of intermediate proximity. With one part of the curriculum having disciplinary proximity and two parts that do not, this case represents the loosest disciplinary fit of VHS and the selected fields of study. In teacher training, no significant differences were observed and thus the first hypothesis is rejected.

The second hypothesis [H2] postulated that in fields of study without disciplinary counterparts at VHS, AHS graduates have higher graduation probabilities than those of VHS. For the selected fields of study, this hypothesis cannot be confirmed. The hypothesis [H3a] that in humanities and languages, AHS with a focus on humanities have higher graduation probabilities than AHS with a focus on natural sciences is supported. However, this is not the case for natural sciences [H3b], where AHS with a focus on natural sciences do not exhibit higher graduation probabilities than AHS with a focus on humanities.

In most of the selected fields of study, the school type that is a disciplinary counterpart or has disciplinary proximity to that field of study, has a higher graduation probability than other school types, thereby supporting previous research that has demonstrated a positive impact of domain-specific prior knowledge on subsequent educational success (Fischer et al. 2020; Sadler and Tai 2007). Furthermore, the higher effect sizes of prior education in engineering, ICT, and architecture, in comparison to the comparatively smaller differences among school types in the social sciences, are in line with Fischer et al. (2020). In addition to Farías and Sevilla (2015), who showed that students from vocational upper secondary schools in Chile are more likely to succeed in vocational tertiary education within the same field than students from other school types, the results of this study indicate that in Austria this is true for both types of higher education institutions, the vocational-oriented UAS and universities.

A limitation of this study is that the hypotheses are based on theoretical considerations of domain-specific prior knowledge, yet the level of knowledge itself was not assessed. Consequently, further research is required to ascertain whether prior knowledge is the primary or sole influencing factor, or whether there are other contributing factors that explain the higher graduation probabilities of students from schools that are disciplinary counterparts. Therefore, it is necessary to assess prior knowledge in the varying domains at the individual level. Furthermore, it would be beneficial to refine the definition of disciplinary counterparts and disciplinary proximity in further research. In this paper, this definition was assigned to school types and fields of study. To gain a more precise definition it would be necessary to consider the profile of each school – or, in education systems where students can choose their majors in upper secondary school, the profile of each student – and the curriculum of each study programme. The construction of a quantifiable metric may provide further insights into the importance of disciplinary proximity and its influence on student success in higher education.

Nevertheless, the analysis yields several implications. From a micro level perspective, the findings suggest that adolescents and their parents must be aware that the system's inherent promise that all pathways into and through higher education are open after a VHS is only partially fulfilled. A 14-year-old student who is confident in their disciplinary interests but uncertain about their future academic aspirations may find a good fit in a VHS. However, if the student is uncertain about their disciplinary interests, a VHS may be a problematic choice, as changing disciplines after upper secondary level appears to be more challenging than the formal structure of the education system suggests. On a meso-level, higher education institutions that want to improve student success may implement student support measures such as bridging courses or elective courses for students who change disciplines between upper secondary and tertiary levels. A more innovative approach would be to introduce additional courses for pupils of VHS who have developed other interests by the third or fourth grade of VHS (age 16–17). For instance, engineering courses could be made available to pupils of business and pedagogical VHS. Such courses could be provided by higher education institutions and awarded as micro-credentials. Finally, for the macro-level perspective, the findings offer new insights for the ongoing debate surrounding school tracking. For instance, low graduation rates among specific school types in particular fields of study may indicate a lack of efficiency within the education system. The concept of disciplinary counterparts may also prove fruitful for further research on how educational inequalities, such as gender segregation, are shaped.

Note

1. The translations of the various school types presented in this paper were chosen with the objective of enhancing readability. For example, alternative translations may be 'academic secondary school' instead of 'academic high school', and 'college of higher vocational education' instead of 'vocational high school'. The original names in German and direct translations for different types of vocational high schools include terms such as 'higher school', 'higher educational institution', and 'academy'. These names may be misleading because they make the school types sound more distinct than they actually are.

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Hyperlink the transparent peer review policy highlighted in yellow in the Supplementary footnote and Disclosure statement and that link will need to be taken to Submit to European Journal of Higher Education (tandfonline.com)

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Ethics declaration

Access to register-based micro data was provided via the Austrian Micro Data Center (AMDC) of Statistics Austria in accordance with national legislation (Bundesstatistikgesetz § 31). The AMDC

provides micro data for accredited research institutions via remote access. All outputs are controlled by Statistics Austria to guarantee compliance with data protection guidelines, thereby ensuring that the de-anonymisation of individuals is impossible (for further details see Fuchs et al. 2024).

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