Social Inclusion
2025 • Volume 13 • Article 9638
https://doi.org/10.17645/si.9638

ARTICLE

Open Access Journal

Can Educational Policy Influence Major Choices in Higher Education Through Changes in School Curriculum?

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Submitted: 18 November 2024 Accepted: 10 March 2025 Published: 8 May 2025

Issue: This article is part of the issue "The Role of Contexts in the Educational and Employment Transitions and Pathways of Young People" edited by Alexandra Wicht (Federal Institute for Vocational Education and Training / University of Siegen), Oliver Winkler (Martin Luther University Halle-Wittenberg), Mona Granato (Federal Institute for Vocational Education and Training), and Alexandra Nonnenmacher (Worms University of Applied Sciences), fully open access at https://doi.org/10.17645/si.i418

Abstract

The impact of high school curriculum reforms on students' major choices in higher education remains an underexplored field, despite their potential role in shaping workforce composition, economic development, and social mobility. This study addresses this gap by examining the varying emphasis on compulsory school subjects across German states. We focus on non-core subjects that vary significantly in importance across states (civic education) or that are part of the curriculum in some states but not in others (economics and computer science). These subjects are increasingly recognized as essential for fostering democratic values, economic understanding, and digital literacy, which also shape students' career aspirations and educational trajectories, ultimately contributing to a skilled workforce and potentially reducing the shortage of skilled labor. Using a novel dataset documenting state-specific introduction of compulsory courses and instructional time from 1995 to 2018, we analyze their influence on major choice. This dataset is linked with German higher education register data to assess whether increased compulsory instruction time and the introduction of compulsory courses affect students' subsequent major choices. For our analyses, we employed two-way fixed effects models to examine whether changes in the curriculum led to changes in major choices. Our results indicate small but positive effects of additional compulsory hours in civic education and economics on related major choices. However, our findings for computer science courses remain inconclusive. These results, along with the methodological limitations identified, highlight the need for further research on the long-term educational implications of school curriculum reforms.

Keywords

civic education; computer science; curriculum reform; economics; educational context; educational policy; major choice

1. Introduction

Curriculum reforms in high schools can play a crucial role in shaping students' educational pathways, including their choice of majors in higher education. These reforms, often implemented to align education with evolving pedagogical trends, technological advancements, and societal needs, aim to enhance both specific academic outcomes and broader societal goals, such as labor market integration and civic engagement. However, the extent to which these changes impact students' long-term educational trajectories and major choices in higher education remains insufficiently explored.

Research indicates that changes in high school curricula can shape students' interest in particular subjects, influencing their future educational decisions, including their choice of majors in higher education. By providing varying levels of exposure to different subjects, school curricula create opportunities for students to assess their interests and competencies (Legewie & DiPrete, 2014). However, most research on curriculum reforms has concentrated on core subjects or sought to explain gender disparities in major choices (see also Jacob et al., 2020; McNally, 2020). Consequently, there remains a notable gap in research regarding the effects of reforms in non-core subjects such as civic education, economics, and computer science. These subjects are increasingly recognized as essential for fostering democratic values (e.g., Sendzik et al., 2024), economic understanding (e.g., Kaiser & Menkhoff, 2016), and digital literacy (Liu et al., 2024). Furthermore, exposure to these subjects may shape students' career aspirations and educational trajectories, which, in turn, have broader implications for society, politics, and the economy. For instance, a well-educated and digitally literate workforce can drive economic development by enhancing productivity and innovation. Additionally, fostering democratic values through education can promote social mobility and political engagement, ensuring that citizens are equipped to participate actively in democratic processes. Moreover, addressing the shortage of skilled labor through targeted educational initiatives can strengthen the overall workforce, contributing to economic stability and growth.

Against this background, we pose the broader question: To what extent can education policy shape students' future choice of major in higher education through changes in the compulsory high school curriculum in certain non-core subjects?

To answer our research question, we employed a quasi-experimental research design to examine the impact of curricular changes in the non-core subjects of civic education, economics, and computer science. The study takes advantage of Germany's system of educational federalism, which gives the 16 federal states (*Länder*—hereinafter states) primary decision-making authority in school-related matters. This system has engendered a diversity of curricula in the 16 states over time, particularly in terms of the introduction and the number of hours devoted to the non-core subjects that are the focus of this study. Conversely, the school systems share important similarities, such as the allocation of students to different school tracks after primary school and the acquisition of the *Abitur* as a prerequisite for university admission. In addition, unlike in other countries, all German students pursuing the academic track (*Gymnasium*) in lower secondary school must enroll in all core and non-core subjects at the same level, and there are very few opportunities to take additional subjects voluntarily. Specifically, this study exploits state-level curriculum changes over a 24-year period. We use a novel dataset derived from high school curricula in lower secondary education across Germany's 16 states, covering graduate cohorts from 1995 to 2018, combined with register data on all students in higher education in Germany.

This article contributes to the literature on the impact of curriculum reforms on major choices in higher education in three ways. First, it examines how curriculum reforms during compulsory education influence major choices in higher education. While previous research has primarily focused on the choice of curricular tracks in secondary education or subjects in upper secondary education and their subsequent impact on major choices (e.g., Barone & Assirelli, 2020; de Philippis, 2021; Jacob et al., 2020), our study investigates the earlier period when students have very limited choice, and individual selection into subjects is not yet prominent. Second, it highlights changes to the curriculum regarding non-core subjects, an area often overlooked in research that predominantly focuses on core subjects or STEM fields (science, technology, engineering, and mathematics; see, e.g., Darolia et al., 2020; Goodman, 2019; Görlitz & Gravert, 2018). Finally, our research expands the sociological literature on educational choices by emphasizing institutional-level factors. While a substantial body of research examines individual-level or societal influences on major choice, fewer studies consider the role of institutional changes. Our article contributes to this body of knowledge by examining the impact of educational policies, particularly those related to non-core subjects, on educational trajectories.

2. Theoretical Considerations and State of Research

Existing research has already explored several factors influencing both university admissions and the choice of specific fields, particularly in STEM areas (e.g., Altonji et al., 2012; McNally, 2020). These factors operate at various levels: micro (individual), meso (institutional), and macro (societal; see, e.g., Hadjar & Becker, 2009). At the micro level, decisions are shaped by personal abilities, personality traits, decision-making processes (e.g., expected income), and socio-demographic factors like gender and social background (e.g., Card & Payne, 2021; Erdmann et al., 2023; Mentges & Spangenberg, 2021). At the macro level, influences include gender roles associated with specific occupations, labor market trends, and sector-specific unemployment rates (e.g., Makarova et al., 2019; Peter et al., 2024). Studies that focus on the meso level examine the role of institutions—particularly educational institutions—in shaping educational choices, viewing them as modifiable through policy. These studies investigate how institutional factors, such as tuition fees, admission requirements, mentoring programs, and the local university landscape, correlate with educational inequality and the alignment between individual preferences and societal needs (e.g., Aucejo & James, 2021; Declercq & Verboven, 2018; Engelhardt & Lörz, 2021; Erdmann et al., 2023; Neugebauer et al., 2016; Shin & Milton, 2008; Suhonen, 2014).

To our knowledge, the influence of the regulation of school curricula on students' major choices in higher education has received rather little attention compared to the other factors mentioned above. And if so, then particularly concerning gender differences in STEM (see also Jacob et al., 2020; McNally, 2020). The underlying theoretical assumption is that school subjects can influence interest in certain content (positively and negatively) and thus later educational pathways, such as a major choice in higher education. Thus, by varying levels of exposure to different subjects, school curricula create opportunities for students to assess their interests and competencies (Legewie & DiPrete, 2014) and enhance subject-related performance and self-efficacy (Görlitz & Gravert, 2018). In this context, the degree of standardization within school systems, particularly concerning the freedom of subject choice, plays a crucial role. According to Jacob et al. (2020), a "paradox of choice" (Jacob et al., 2020, p. 63, as cited in Abbiss, 2009, p. 345) may emerge due to the increasing influence of individual and social factors, such as social norms, on subject choice when these courses can be taken voluntarily. This, in turn, can reinforce the educational trajectory already being pursued (Humphries et al., 2023). Conversely, compulsory school subjects are expected to expose groups of students to certain content they might otherwise miss due to selection based on their interests, family socialization, or other contextual factors. In light of this theoretical consideration, school subjects and their political-administrative design can be considered as an important institutional factor in the analysis of major choices in higher education.

The validity of this assumption is examined by a few studies that utilize longitudinal individual-level data analyzing the *general effect* that changes in high school curricula may have on major choices in higher education (on the effects of high school subjects on later stations in the educational and life course see, e.g., Biewen & Schwerter, 2021; Goodman, 2019; Jia, 2021). Since curriculum reforms are typically not designed to favor specific groups, this article focuses on the general effect. Accordingly, we report only the results from studies that directly address this issue. While studies that focus solely on gender differences, such as Görlitz and Gravert (2018), Joensen and Nielsen (2014), and Bertocchi et al. (2021), are mentioned here, they are not discussed in detail, despite their significant importance, particularly when examining differences between subgroups. The studies that focus on the general effect mostly focus on educational policy reforms leading to changes in high school curricula in upper secondary education, which are occasionally accompanied by new requirements for teaching content and quality. These studies mainly examine the variation in instructional time across schools and states using quasi-experimental research designs (for variation in teaching content while teaching time remains constant see Morando, 2024). The findings of Broecke (2013) and de Philippis (2021) suggest, for example, that England's reform to increase instructional time in science (physics, chemistry, biology) for high-ability students had a (small) positive impact, particularly on their subsequent decision to study STEM subjects. In the context of the introduction of advanced computer science courses in schools in the US state of Maryland, Liu et al. (2024) find that students who have taken these courses are more likely to go on to study computer science in higher education. In a cross-national study (Germany, Ireland, Scotland), albeit without a quasi-experimental research design, Jacob et al. (2020) show that pursuing more STEM subjects in upper secondary school is associated with a higher enrollment rate in a STEM degree program. In contrast, Darolia et al. (2020) find no effect of taking more math and science courses in the US state of Missouri on subsequent enrollment in a STEM degree program.

Despite the existing research, uncertainty remains about the general effect of school subjects on major choices in higher education, as selection processes are structurally embedded in the school contexts analyzed in current studies, such as through the free choice of courses. To our knowledge, only the study by Hübner et al. (2017) provides more evidence on compulsory subjects. They utilized the curriculum reform implemented for the final two years of academic high school in the German state of Baden-Wuerttemberg, which students commence at an average age of 17. For all students, advanced courses in German, mathematics, and a foreign language, as well as attendance in at least two science courses, became mandatory, although the total number of hours for advanced courses was reduced by one hour per week. The results of Hübner et al. (2017) suggest that the reform did not lead to an increased number of students taking a STEM subject (for gender-specific effects see Görlitz & Gravert, 2018).

Existing research has provided valuable insights into how school subject choices impact major selection in higher education. Studies have primarily focused on the later stages of schooling, where students actively select curricular tracks in secondary education or place greater emphasis on particular subjects in upper secondary school, both of which influence their eventual major choices (e.g., Barone & Assirelli, 2020; Jacob et al., 2020).

Despite these contributions, significant gaps remain. First, there is limited research examining how curriculum reforms during compulsory education—when students typically have minimal choice— impact future major decisions. This early educational phase is critical, as students' exposure to different subjects may shape their interests before individual selection becomes prominent. Additionally, while much of the existing literature prioritizes core academic subjects and STEM fields (e.g., Görlitz & Gravert, 2018), studies rarely address the influence of non-core subjects. This gap may oversee the potential impact of a broader curriculum on students' academic trajectories. Finally, fewer studies explore how institutional-level factors, particularly educational policies setting high school curricula, shape major choices. Much of the existing research emphasizes individual or societal influences, but understanding how policies on non-core subjects affect students' choices could provide a clearer picture of the pathways leading to higher education majors.

Overall, we investigate whether educational policy measures mandating attendance in certain school subjects will lead to changes in enrollment rates in similar subjects at the university level. However, this approach is exploratory without using directional hypotheses, given the limited and, at times, mixed evidence currently available.

3. Institutional Background

3.1. The German High School and Higher Education System

Although Germany has a standardized educational system, each of its 16 states maintains autonomy in shaping its specific features through its own educational policies (Helbig & Nikolai, 2015). A key feature of the German school system is its early tracking structure. Compulsory education begins at the age of six, when children enter elementary school, which typically lasts four or six years, depending on the state. At an early age (10 or 12), students are assigned to one of three hierarchically structured tracks based on the recommendations of their primary school teachers and the decisions of their parents. Selection is formally based on students' abilities and achievements. Thus, students' choices are limited and depend on external factors. The academic track (*Gymnasium*), which is the focus of this study, leads directly to the higher education qualification (*Abitur*). The number and nature of these tracks have shifted over the past few decades and vary between states (Becker et al., 2016). An increasing number of states offer the possibility of taking the *Abitur* examination at a school track other than a *Gymnasium*. However, the majority of students at university graduate from a *Gymnasium* (Spangenberg & Quast, 2023).

The *Gymnasium* is divided into two successive stages: lower secondary education (up to the age of 15 or 16) and upper secondary education (up to the age of 18 or 19; see also Görlitz & Gravert, 2018; Jacob et al., 2020).

The degree of standardization at the *lower* secondary level, which is the focus of our study, has undergone minimal changes across states during the period under investigation (graduation cohorts from 1995 to 2018). Apart from a few optional courses and electives, all students are obliged to take all subjects at the same level and for the same number of hours within states and school tracks. Despite the similarity of the lower secondary education of the *Gymnasium* between the states in terms of compulsory education, disparities emerge in the educational policy priorities of the states, manifesting in the composition of the curriculum (i.e., different subjects) and the number of hours devoted to them. Differences primarily pertain to non-core subjects, including computer science, economics, and civic education.

The degree of standardization at the *upper* secondary level was characterized by a certain degree of freedom in many states until the 2000s. Since the beginning of the 2000s, however, more and more states have increased the degree of standardization by expanding the compulsory lessons in the core subjects (Trautwein et al., 2010). Furthermore, the duration of upper secondary education was reduced from three to two years in most states at different times since the 2000s (though many states later returned to three years). These alterations led to overall changes in enrollment in higher education but did not significantly affect the choice of majors among high school graduates of our interest, namely political and social science, economics, and computer science (Marcus & Zambre, 2017, 2019).

Access to the higher education system in Germany and admission to certain subjects is characterized by the following general conditions (see also Jacob et al., 2020). Unlike in other countries, the *Abitur* in Germany entitles students to choose any subject at university. Proof of successful completion of certain advanced courses at the school is not required. The choice of a specific subject is made with the application to a university. However, highly sought-after subjects (e.g., medicine, pharmacy, psychology) and study locations (e.g., Berlin) impose admissions restrictions based on the overall *Abitur* grade, known as the *numerus clausus*, which sets the threshold for admission to a specific subject. To our knowledge, the subjects of our interest were not or only slightly affected by (strict) *numerus clausus* admission restrictions (see also Reimer & Pollak, 2010). In addition, between 2005 and 2013, certain German states introduced tuition fees of approximately €500 per semester, irrespective of the subject. However, these did not appear to have a negative impact on the general propensity to study (Helbig et al., 2012). The so-called Bologna Process also falls within our study period. This reform process, which began in 1999, led German universities and faculties to gradually convert the previously common diploma and master's degree programs, as well as teacher training programs that culminated in a state examination, into bachelor's and master's degree programs. However, the reform does not appear to have changed the choice of a particular field of study (Horstschräer & Sprietsma, 2013) and has affected all states equally.

3.2. The Curriculum Reforms

To examine the influence of civic education, economics, and computer science on the choice of major, we exploit the variation in these subjects in the lower secondary curriculum across time and states. Specifically, we focus on educational policy reforms that have led to (a) changes in compulsory school hours and (b) the introduction of compulsory courses at the lower secondary level, which, during our observation period, occurred only for economics and computer science. Drawing from existing historical work, the objectives and history of these subjects can be categorized as follows. However, given the limited extent to which the reform process is described, we refer here to examples from our own data collection on the reforms (see also Section 4 for more details).

Since the beginning of the Federal Republic of Germany, the school subject of civic education has been assigned an important function in the democratization of the population (Sendzik et al., 2024). Course goals include the development of an understanding of democratic and constitutional principles and critical engagement with political and social issues. Since the late 1960s, civic education has been a compulsory subject in all states. However, the implementation of reforms within the states has resulted in fluctuations in the number of hours allocated to this subject over time. For example, due to the 1991 reform in Lower

Saxony, the graduating cohort of 2000 received three more hours of civics per week compared to the graduating cohort of 1996.

Since the turn of the millennium, discussions and calls for economics as a compulsory subject have intensified (Retzmann & Seeber, 2022). The objective is to empower young people to develop into responsible economic citizens and consumers by engaging with economic issues in the classroom setting. Consequently, at least economics became an official component of so-called integration subjects (e.g., politics/economics in North Rhine-Westphalia, since the school year 2007/08). However, even prior to this development, economic content was part of subjects such as work studies (e.g., in Hesse, since the school year 1976/77). During the period under review, 13 out of 16 states introduced economic education as part of a compulsory (integrated) subject at various times.

Since the mid-2010s, there has been increasing discussion about the introduction of computer science as a compulsory subject (SWK, 2022). One of the aims of computer science is to help students better meet the challenges of an increasingly digital (working) environment. During the reporting period, seven out of 16 states introduced computer science as a separate subject (e.g., Saxony) or as part of a (integrated) subject (e.g., Mecklenburg-Western Pomerania in the 1990s).

4. Data and Analytical Strategy

4.1. Data and Variables

Our dataset includes data from the Federal Statistical Office, which provides information on higher education and school statistics. This data has been supplemented with a specially compiled dataset drawn from the timetables of the 16 states (Sendzik et al., 2024). All information collected pertains to the cohort of high school graduates (only of *Gymnasium*) in Germany from 1995 to 2018.

The dependent variable—the enrollment in certain majors in higher education—was identified using register data of all students enrolled in higher education in Germany (Research Data Centres of the Federal Statistical Office and Statistical Offices of the Federal States of Germany, 2022). All German higher education institutions are required to report information on their students to the Federal Statistical Office and the Statistical Offices of the Federal States, which provide the data in anonymized form for research purposes. The dataset includes students' demographic information (e.g., gender and age), study choices (e.g., the year and university of first enrollment, the choice of major in higher education), and high school background (e.g., the year and state of high school graduation, and the type of high school). For our analysis, we utilized data from high school graduation cohorts spanning from 1995 to 2018.

Using this dataset, we calculated our dependent variable as the share of first-semester students who enrolled in fields of interest, for each graduation cohort and by state. For civic education, we included majors in political and social sciences. For economics, we included majors in economics and business management, encompassing specializations such as tourism management, sports management, or health management. For computer science, we included majors in computer science with specializations such as health informatics, bioinformatics, or information systems.

Our two main independent variables are: (a) the changes in compulsory instruction hours and (b) the implementation of compulsory courses in lower secondary education. They were analyzed using both a new dataset for civic education (Sendzik et al., 2024) and new data for economics and computer science collected for this article. Specifically, we utilized information from the so-called secondary school timetables. These timetables are used by education policymakers to set the instruction time for school subjects. The datasets provide information for each state and each cohort on the number of compulsory hours per week for subjects ranging from grades five to ten (ages 10 to 16).

4.2. Analytical Strategy

Due to differences in the implementation of the three subjects during our observation period, we first examine how changes in the number of school hours affected all three subjects. Secondly, we analyze how the introduction of economics and computer science courses, irrespective of instructional hours, influenced students' major choices in higher education.

To address our research question—to what extent do changes in high school curricula in specific non-core subjects influence students' future major choices in higher education—we employ two-way fixed effects (TWFE) models (e.g., Callaway et al., 2024; Imai & Kim, 2021) using two different codings of the independent variable.

First, we apply analyses using a continuous independent variable to account for longitudinal variations in treatment intensity. This approach allows us to examine the influence of changes in instructional hours within a state over time. By leveraging within-state variations across multiple years, we gain insight into how changes in instructional policies impact higher education enrollment trends within each state when the subject is already implemented.

Second, we employ the same two-way fixed effects approach but with a binary-coded independent variable, disregarding treatment intensity. This allows us to estimate the difference in the dependent variable between two groups (e.g., with and without instruction time) while controlling for fixed effects. By examining the average effect (binary coding) of instructional time, we exploit the fact that economics and computer science were newly introduced during our observation period. Here, our primary interest lies in assessing whether the introduction of these subjects, regardless of instructional hours, influenced students' major choices. This analysis may provide valuable insights for policymakers when discussing the general implementation of new subjects in high school curricula.

For all models, we include year-fixed effects by incorporating year dummies to account for national trends. Furthermore, we conduct several robustness checks, which are described in more detail in Section 6.

Our chosen research design, which includes both entity and time-fixed effects, strengthens our ability to infer causality by addressing key challenges related to unobserved heterogeneity, omitted variable bias, and endogeneity (Brüderl & Ludwig, 2015). Nevertheless, there is a broad critical discussion about the use of TWFE for causal inference, underscoring its potential pitfalls in the context of longitudinal data (see, for instance, Callaway et al., 2024; Imai & Kim, 2021). Together, these approaches allow us to examine the relationship between secondary school instructional time in specific fields and higher education enrollment in related majors, accounting for both the intensity of exposure to a subject and the timing of its introduction across different regional and temporal contexts.

5. Results

As the collected data is novel, we begin by presenting descriptive figures and statistics for both the independent and dependent variables before turning to our main results in the second part of this section.

Figures 1 to 3 illustrate the evolution of instructional hours (independent variable) for all three subjects across states. Analyzing these patterns reveals four key characteristics: First, there was considerable variation in the timing of implementation across states, meaning that the periods defining pre- and post-treatment conditions differed by region. Second, the intensity of the treatment—defined by the number of instructional hours allocated to each subject at the time of its implementation—also varied between states, reflecting policy decisions that adjusted instructional time based on regional educational priorities and resources. Third, treatment intensity was not static within several states, with instructional hours undergoing modifications over time, and some states increasing or decreasing instructional time in certain subjects after the initial implementation period. Fourth, our study period (covering graduates from 1995 to 2018) coincides with a phase in which civic education was consistently part of the high school curriculum in almost all states (with exceptions being Schleswig-Holstein and Bavaria, see also Table A1 in the Supplementary File).

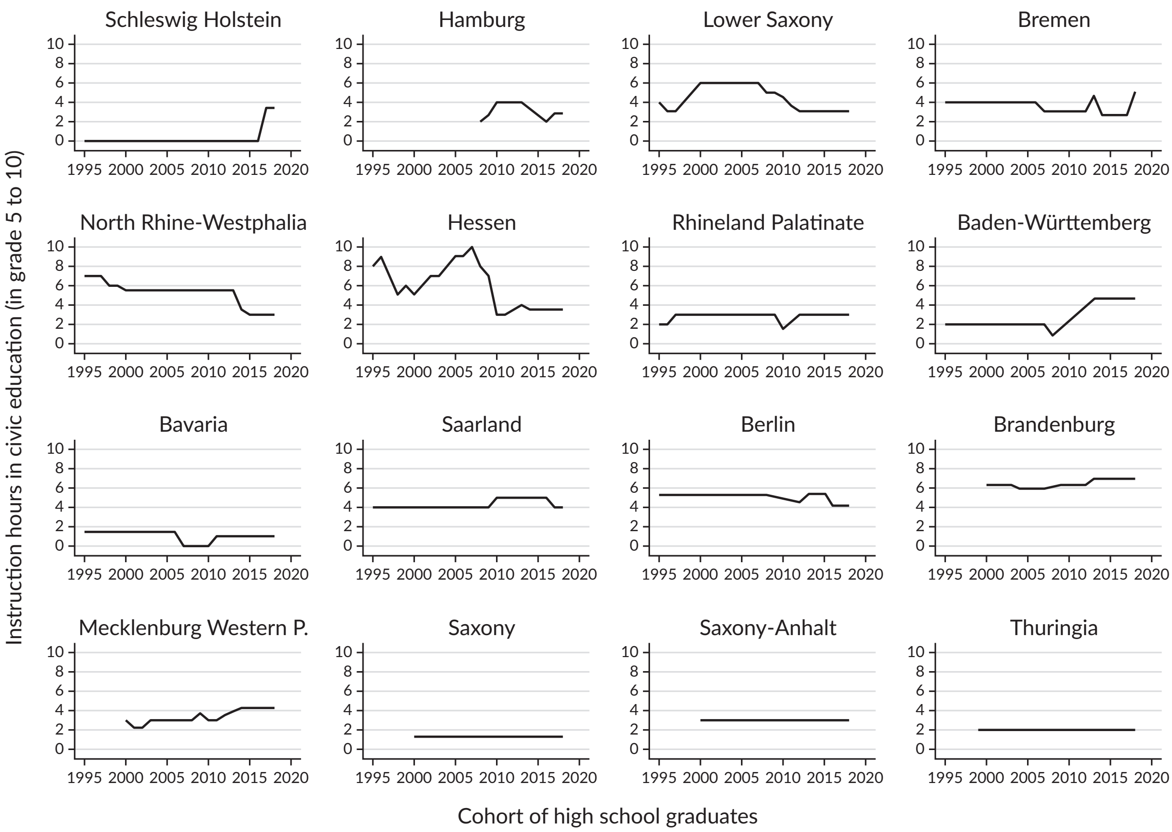

Figure 1. Number of hours in civic education over time by state.

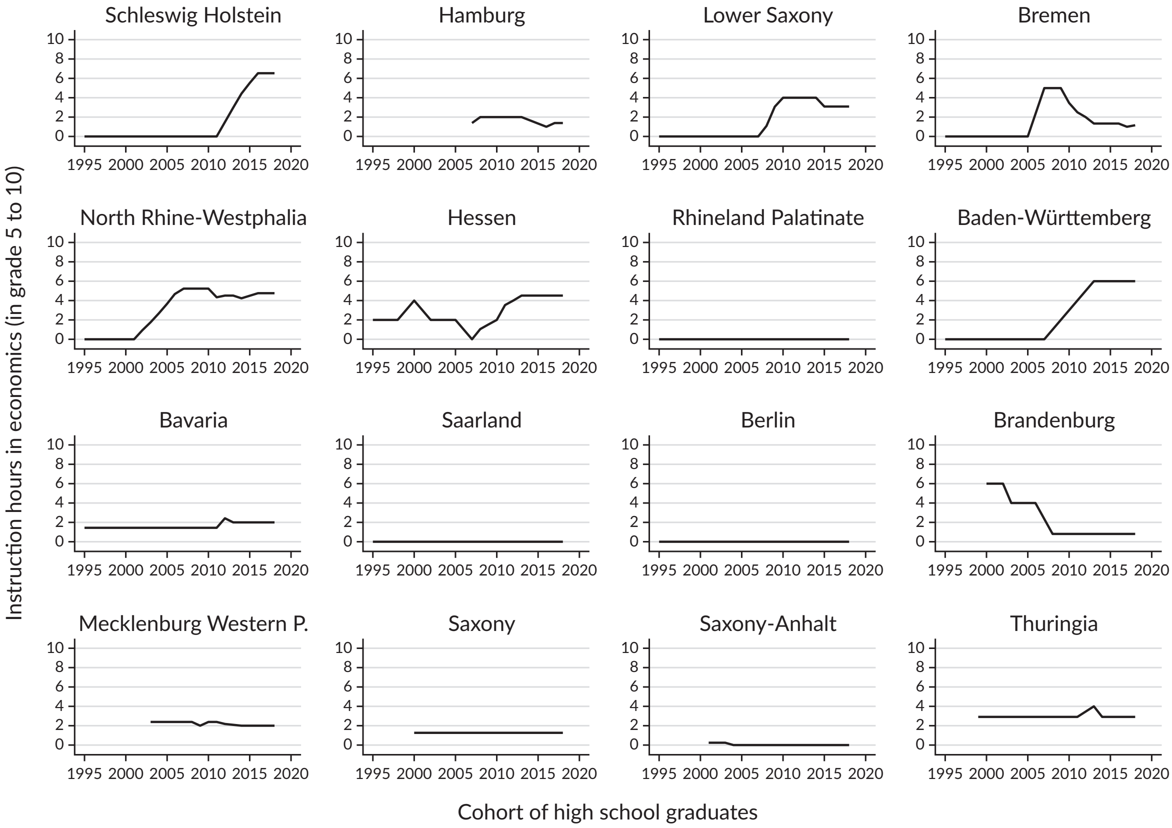

Figure 2. Number of hours in economics over time by state.

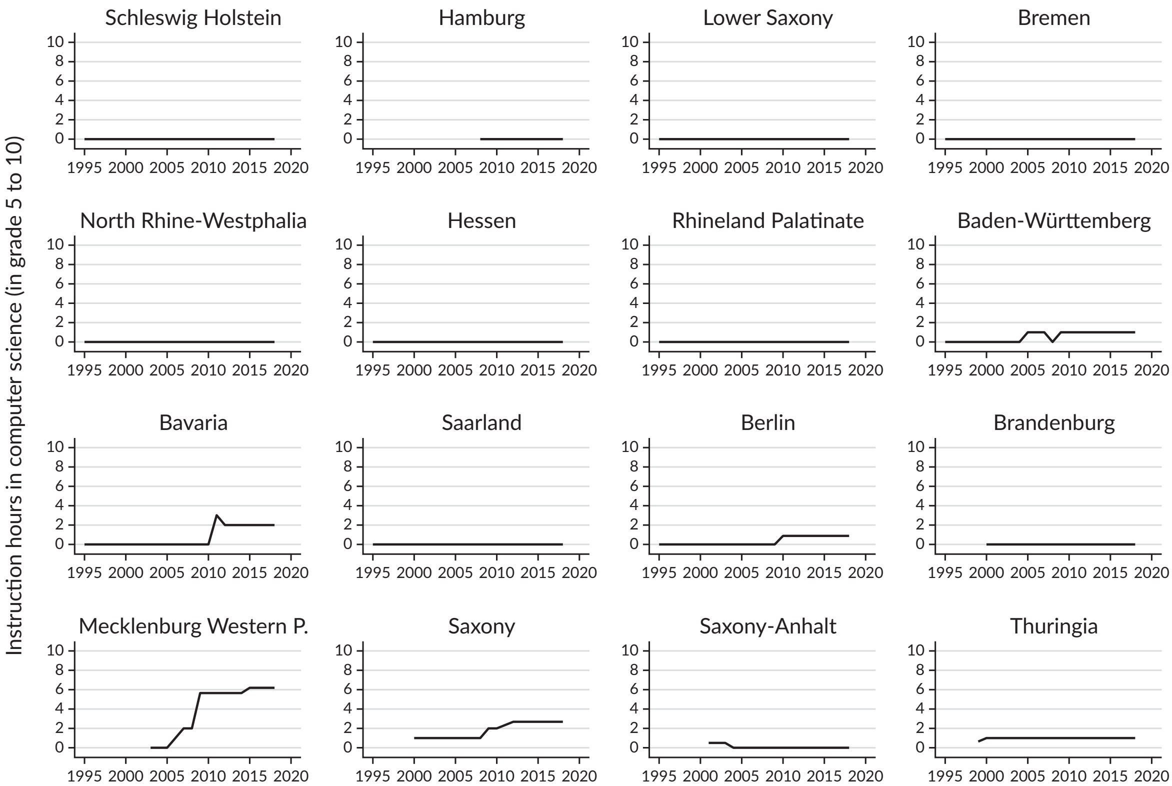

Figure 3. Number of hours in computer science over time by state.

Table 1 presents the mean share of first-semester students enrolling in specific majors in higher education (dependent variable), disaggregated by state and instruction in the respective subjects, for descriptive purposes. Since civic education was implemented in nearly all states throughout the observation period, values for cohorts without instruction are displayed only for the two states where implementation varied. A comparison of the mean values by state for economics reveals that, in almost every state where a change in implementation status occurred, the cohorts with instruction time in economics exhibited a lower share of first-semester students in this major than the cohorts without instruction time. This pattern indicates that the introduction of economics instruction is associated with a decline in the share of students choosing this major. However, it is important to note that we observe an overall decline in economics enrollments over time, independent of implementation status (not shown here). This trend coincides with the introduction of economics instruction, suggesting that broader national patterns in economics enrollment may be influencing this outcome. For computer science, by contrast, we observe the opposite pattern, with the share of first-semester students being generally higher in cohorts that received instruction in this subject.

Table 1. Distribution of share of first-semester students in a specific major in higher education.

State	Civic Education				Economics				Computer Science			
	Without mean	(n)	With mean	(n)	Without mean	(n)	With mean	(n)	Without mean	(n)	With mean	(n)
Schleswig-Holstein	0.050	(22)	0.038	(2)	0.191	(17)	0.188	(7)	0.062	(24)	n/a	(0)
Hamburg	n/a	(0)	0.044	(11)	n/a	(0)	0.207	(12)	0.062	(11)	0.052	(0)
Lower Saxony	n/a	(0)	0.062	(24)	0.171	(13)	0.161	(11)	0.050	(24)	n/a	(0)
Bremen	n/a	(0)	0.066	(24)	0.205	(11)	0.169	(13)	0.065	(24)	n/a	(0)
North Rhine-Westphalia	n/a	(0)	0.046	(24)	0.180	(7)	0.151	(17)	0.047	(24)	n/a	(0)
Hessen	n/a	(0)	0.066	(24)	0.205	(1)	0.171	(23)	0.050	(24)	n/a	(0)
Rhineland Palatinate	n/a	(0)	0.063	(24)	0.164	(24)	n/a	(0)	0.059	(24)	n/a	(0)
Baden-Württemberg	n/a	(0)	0.041	(24)	0.172	(13)	0.186	(11)	0.054	(11)	0.064	(13)
Bavaria	0.044	(4)	0.060	(20)	n/a	(0)	0.162	(24)	0.048	(16)	0.069	(8)
Saarland	n/a	(0)	0.044	(24)	0.161	(24)	n/a	(0)	0.056	(24)	n/a	(0)
Berlin	n/a	(0)	0.043	(24)	0.160	(24)	n/a	(0)	0.058	(15)	0.069	(9)
Brandenburg	n/a	(0)	0.042	(19)	n/a	(0)	0.157	(19)	0.067	(19)	0.076	(0)
Mecklenburg Western P.	n/a	(0)	0.054	(19)	n/a	(0)	0.162	(16)	0.054	(3)	0.063	(13)
Saxony	n/a	(0)	0.043	(19)	n/a	(0)	0.141	(19)	n/a	(0)	0.060	(19)
Saxony-Anhalt	n/a	(0)	0.056	(19)	0.145	(15)	0.196	(3)	0.057	(15)	0.072	(3)
Thuringia	n/a	(0)	0.058	(20)	n/a	(0)	0.144	(20)	n/a	(0)	0.061	(20)

In Table 2, we present the results for the effect of instruction time on major choice in higher education across all three subjects. Models 1 to 3 include estimates based on the metric independent variable (instruction time), while Models 4 and 5 display results for economics and computer science using a binary coding of instruction time.

For civic education, the results indicate a small but significant increase of 0.1 percentage points in the proportion of students who choose political or social science as their major in higher education (see Model 1). Given that the baseline enrollment rate in these majors within our model is 5.3%, this 0.1 percentage point rise corresponds to a 1.9% relative increase in political or social science enrollment per additional hour of civic education. The mean instruction time for civic education across all observations is 3.45 hours (see Table A1 in the Supplementary File). Thus, if civic education were implemented with an average of 3.45 hours, this would lead to an estimated 6.5% relative increase in the proportion of students choosing these fields compared to a scenario where no instructional time in civic education is offered. This finding highlights the potential impact of increased civic education on students' career pathways in political and social sciences.

For economics, we observe a significant increase of 0.2 percentage points in the proportion of students who choose economics as their major in higher education (see Model 2). Although this effect appears to be twice as large as the effect for civic education, its relative impact is smaller in relation to the baseline enrollment in economics of 15.5%. Specifically, this 0.2 percentage point increase represents only a 1.3% relative rise in economics enrollment.

Conversely, for computer science, our results indicate a decrease of 0.2 percentage points in the proportion of students who choose computer science as their major in higher education (see Model 3). While the absolute effect size is similar to that observed for economics, its relative impact is notably larger when considered in relation to the baseline enrollment rate. Given that the baseline enrollment rate for computer science in our model is 3.6%, this 0.2 percentage point decline corresponds to a 5.6% relative decrease, making it a more substantial proportional effect compared to the relative changes observed for civic education (1.9%) and economics (1.3%).

Table 2. Results for the instructional time effect on the share of students within these fields in higher education.

	Model 1	Model 2	Model 3	Model 4	Model 5
	Civic Education	Economics	Computer Science	Economics	Computer Science
hours in civic education	0.001***				
hours in economics		0.002***			
hours in computer science			−0.002***		
economics provided (0/1)				0.010***	
computer science provided (0/1)					0.003**
Constant	0.053***	0.155***	0.036***	0.153***	0.035***
Observations	347	344	343	344	343
Number of States	16	16	16	16	16
R^2 within	0.566	0.554	0.816	0.553	0.814
R^2 between	0.025	0.020	0.102	0.045	0.063
R^2 overall	0.312	0.270	0.722	0.237	0.721

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; all models with time-fixed effects while coefficients for the time dummies are not displayed here.

In addition to the analyses utilizing the detailed amount of instruction time as an explanatory variable, we also present the results for economics and computer science with binary coding (Models 4 and 5). These coefficients describe the average effect of whether economics or computer science was offered in school. Since civic education was implemented across most states throughout the entire observation period (with exceptions being Schleswig-Holstein and Bavaria, see Table A1 in the Supplementary File), we were unable to apply this approach to civic education.

For economics, our results indicate a significant average effect of 1 percentage point for instruction in economics. On average, the implementation of instruction time in economics resulted in a 6.5% relative increase in the baseline enrollment rate in economics in higher education.

Notably, for computer science, we found an opposite average effect compared to the model with instruction time as a continuous variable (Model 3 vs. Model 5). In the model estimating the average effect across all variations of instruction time, the results indicate that the implementation of computer science increased the proportion of students who choose computer science as their major in higher education (Model 5). Thus, our results regarding the effect of instruction time in computer science are not robust across different model specifications.

To test whether this inconsistency is driven by specific amounts of instruction time, we also estimated a model with instruction time dummies, which capture the effect of varying amounts of instruction time. The results suggest that the negative effect observed in Model 3 is primarily attributable to high levels of instruction time in computer science (specifically, 5 to 6 hours of instruction; see Figure A1 in the Supplementary File). These high levels of instruction time were only provided in one state, namely Mecklenburg-Western Pomerania (see Figure 3 above). Therefore, we hypothesize that the negative effect could also be a state-specific issue and test for differences by excluding Mecklenburg-Western Pomerania from our sample (Table A2 in the Supplementary File). The changes in results indicate a state-specific phenomenon that is potentially driven by other factors, such as a teacher shortage in computer science. For example, during the implementation of computer science in Mecklenburg-Western Pomerania, the demand for specially trained teachers may have increased rapidly due to the sharp rise in instructional hours. It might be possible that this increased demand was not fully met by specially trained teachers over time.

The results presented in this section suggest that instruction time may have an impact on major choices in higher education, with different effects observed across the subjects of civic education, economics, and computer science. For civic education, the results indicate a small but significant increase in the proportion of students choosing political or social science as their major. In economics, a positive effect of instruction time on major choice is observed, but its impact is relatively modest when compared to the baseline enrollment rate, suggesting that the influence of economics instruction on students' decisions may be less pronounced. However, the results for computer science show inconsistencies, with a negative effect on enrollment in the model based on continuous instruction time, but a positive effect when using binary coding.

6. Robustness

As some of our results exhibit limited robustness (e.g., varying findings for computer science), we conducted additional analyses and employed alternative TWFE regression specifications. First, as indicated by our previous analyses and Figure A1 in the Supplementary File, the assumption of a linear additive effect appears to be violated for computer science. To assess whether this also holds for economics, we tested for non-linearity in this field and found a steadily increasing effect with a higher number of instructional hours (see Figure A2 in the Supplementary File). Second, for both economics and computer science, certain states never introduced these subjects during the observation period and were consequently excluded from the TWFE regression. To address this, we re-estimated all models using random effects, incorporating these states into the analysis (see Table A3 in the Supplementary File). Third, while our primary models include year-fixed effects through year dummies, we further refined our estimates by adding control variables that additionally account for the evolution of the number of high school graduates and first-semester students by state and year (Federal Statistical Office, 1997, 1998, 2022). This adjustment allows us to control for variations in both the supply of and demand for higher education (see Table A4 in the Supplementary File). Specifically, by including both the growth rate and the absolute number of high school graduates, we capture substantial shifts in graduate numbers resulting from educational reforms that altered the duration of secondary education during our observation period. For example, one major reform was the transition from the nine-year *Gymnasium* system (G9) to an eight-year system (G8), which was implemented in most states between the early 2000s and the mid-2010s, reducing the duration of secondary education while maintaining the total instructional hours (see also Section 3.1.). As a result, students in affected cohorts graduated one year earlier, leading to a temporary “double cohort” of high school graduates in the respective years. The exact timing varied by state, but in general, these double cohorts occurred between 2007 and 2013. In subsequent years, as some states reverted to the G9 model or allowed schools to choose between G8 and G9, the distribution of graduates stabilized. Since our main dependent variable is the share of first-semester students in a given major, we also account for fluctuations in the total number of first-semester students, which reflect changes in the level of competition for university places. These dynamics are of particular pertinence, as the subjects analyzed—being less restricted in admissions—may serve as alternative options for students unable to secure entry into highly competitive programs, such as medicine. Despite these adjustments, our main results remain consistent across different model specifications and the inclusion of additional control variables, reinforcing the robustness of our findings.

7. Conclusion

This study was motivated by a central question: To what extent can education policy shape students’ future major choices in higher education through changes in the compulsory high school curriculum in certain non-core subjects? Within this scope, we focused particularly on the meso-level—the role of institutions—in shaping educational choices. We assumed that (a) the increase in the number of hours of civics, economics, and computer science at the lower secondary level, as well as (b) the introduction of economics and computer science as compulsory subjects, would lead to changes in enrollment rates in certain fields of study. Our analyses of major choices in higher education and of high school curricula (timetables) in the 16 German states over a 24-year period for the subjects civic education, economics, and computer science show that mandatory instruction in non-core subjects can influence the choice of major, although the effects vary across subjects.

Analyzing civic education using TWFE models, we found that increasing instruction hours in this subject led to a small but significant increase in enrollment in political and social science majors in higher education. This finding aligns with the expectation that greater exposure to a subject can enhance interest in it. Prior research has suggested that students' engagement with certain topics during school fosters increased interest, which may subsequently influence their choice of study at the higher education level. These results are also consistent with those observed in science education, which indicate that an increase in instruction time can lead to higher enrollment in STEM fields in higher education (Broecke, 2013; de Philippis, 2021).

Our analyses of the effects of both increased compulsory economics instruction and the introduction of economics as a compulsory subject show a positive, albeit small, effect. The results suggest that students' later choice of major is only slightly influenced by the subject of economics in lower secondary school. This relatively small observed effect is somewhat surprising in terms of further research but can be explained by several factors. For example, referring to the 2019 PISA results, Piepenburg and Fervers (2022) highlight that "manager" is among the most desired occupations among the students surveyed. In their study, they examine whether a lack of information contributes to the pronounced emphasis on management careers and the limited range of commonly considered options—the so-called "beaten paths"—in terms of major choices. In our context, the subject of economics may, on the one hand, reinforce some students' aspirations for a managerial career by confirming their belief that studying economics is a necessary step toward that goal. On the other hand, the introduction of compulsory courses in economics has the potential to make some students reconsider their previous preference for economics as a "default major". That is, the opportunity to engage more deeply with the subject through mandatory coursework may lead students to adjust their expectations regarding the study of economics and related career paths, resulting in more informed decisions—and, for some, a decision to opt out of economics. Although our analytical design does not allow us to identify these countervailing mechanisms, they may help explain the relatively small effect of school subjects on major choices. In addition, or as an alternative explanation, the quality of economics teaching may also play a role. In many schools, teachers without an economics specialization are assigned to teach economics, often from the social studies department, at least until appropriately trained new teachers begin teaching in about seven years after the curriculum reforms (Frohn, 2020).

The results concerning compulsory computer science courses are contradictory. On the one hand, our analysis shows a decreasing rate of major choices when the teaching time allocated to computer science is considered. On the other hand, our analysis suggests that the introduction of compulsory courses in computer science has led to an increase in the number of students choosing to major in this subject. Additional analysis indicates that these inconsistent results are due to a violation of the modeling assumptions (assumption of linear additive effect). Further, more detailed analyses indicate that the high number of planned computer science lessons in one state (Mecklenburg-Western Pomerania) suggests the presence of context-specific influencing factors that may have distorted the overall effect. The schools in this state may not have been adequately equipped with the technology needed for effective computer science teaching. In addition, qualified computer science educators were in short supply, and many teachers lacked the specialized training needed to fully engage students in the subject (Schröder et al., 2022; SWK, 2022). We assume that these factors become more important as the number of planned computer science courses increases, resulting in a decline in the quality of instruction and, consequently, in fewer students being interested in pursuing computer science as a major. Alternatively, computer science courses, similar to economics, can provide an opportunity to address students' misconceptions about the field as the number of hours increases, which can lead to a decline in interest as students come to realize that their expectations do not align with the reality of the subject. Thus, the curriculum serves not only as a point of exploration but also as a mechanism for perceptual correction and self-selection among high school students.

Several limitations to our study should be considered when interpreting the findings. First, while we controlled for unobserved heterogeneity and overall trends by design, we could not exclude the potential influence of third variables, such as concurrent reforms or changes in subject composition, which may have affected the results. Previous studies on other reforms (see section 3.1.) generally indicate no effect on major choices; however, we could not rule out the possibility of moderation effects. Additionally, implementing or adding extra hours in the subjects under investigation could lead to a reduction in hours for other subjects, potentially altering the composition of the curriculum. These changes are complex and could not be fully captured across all states over the entire study period.

Given the limited scope of existing research and the methodological constraints of our study, further research is essential to draw definitive conclusions about the impact of high school curriculum changes on students' major choices in higher education. In addition, the findings of our study (especially in the case of computer science) and the current state of research provide mixed results, which currently cast doubt on the ability to make reliable statements about the overall effects of curriculum changes. These uncertainties highlight the need for caution when drawing policy implications from the available evidence, as it may be based on an incomplete understanding of the underlying causal relationships. Consequently, more research on the effects and underlying mechanisms is needed before policy recommendations can be formulated for the concrete implementation of effective curriculum reforms. Future studies should adopt more comprehensive analytical approaches, explore the role of other reforms, the influence of specific teaching content and approaches, and investigate potential regional effects.

Additionally, our study focuses on the general effect on major choices in higher education, as most reforms did not target specific groups and were not designed to be more effective for particular subpopulations. However, research has already identified gender differences concerning major choices, highlighting the importance of analyzing effect heterogeneity across subgroups, such as gender. Prior studies have demonstrated that high school subjects can have a gender-specific influence on students' educational and career trajectories (e.g., Joensen & Nielsen, 2014; Liu et al., 2024). As stated above, exposure to certain subjects may also function as a mechanism for perceptual adjustment in various aspects, such as self-confidence in specific fields or awareness of occupational opportunities in these fields. Research has also shown gender differences in responses to career education, further emphasizing the need to consider gender-specific effects (e.g., Beckmann & Fervers, 2024). Therefore, we emphasize that our results capture only the overall effect of curriculum reforms on the investigated subjects and do not account for group-specific effects. However, based on recent research, we would expect gender differences, particularly concerning STEM subjects, as previous studies have found indications of such relationships. Since the mechanisms underlying gender-specific responses to exposure to these three subjects may vary considerably, a detailed analysis of gender-specific effects falls beyond the scope of this article and remains an important question for future research.

Overall, more robust and detailed data are needed to draw conclusions that can inform the development of educational policies aimed at more effectively shaping students' academic and career trajectories. This could include registry data that allows individual and institutional characteristics in the educational biography to be linked from at least the lower secondary level. The data sets available for Germany, such as the National Educational Panel Study (NEPS) and the Student Life Cycle Panel (SLC), only offer limited potential for analysis.

Acknowledgments

We thank the two anonymous reviewers and the editors for their valuable comments. Our special thanks go to our student assistant Julia Szensny for her valuable support in coding the legal regulations on instruction hours in economics and computer science. We would also like to thank our student assistant Jacqueline Niemietz for her help in identifying relevant majors.

Funding

The article is part of the project "Efficiency and Equity in Education: Quasi-Experimental Evidence from School Reforms across German States" (EffEE), generously funded by the Leibniz Association under its competitive procedure. The open access publication of this article was made possible by the support of the working unit "Structures and Systems" of the Leibniz Institute for Educational Trajectories (LIfBi).

Conflict of Interests

The authors declare no conflict of interest.

Data Availability

The data on hours of instruction in economics and computer science are available upon request from the authors. The data on civic education hours are available free of charge at: https://www.lifbi.de/de-de/Start/Daten-Services/Daten-und-Dokumentation/HISPOL. Microdata from the student statistics from 1995 to 2018 can be obtained from the Research Data Centres of the Federal Statistical Office and Statistical Offices of the Federal States of Germany: https://forschungsdatenzentrum.de/de/bildung/studenten.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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