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Abstract

Most creatives acquire professional talents by learning from others, but in most settings it is difficult to estimate the existence of long-term effects. This paper explores the transmission of skills over a period of more than seven centuries by focusing on the case of music composers. We ask the question: how does a composer's quality influence the quality of the composers he or she teaches? Our analysis builds on a unique dataset of 17,433 composers from around the world since the fourteenth century. By comparing actual teacher–student pairs with plausible counterfactual pairs and by using a two-stage framework, we show a strong effect of quality transmission. Moreover, we find quality transmission persists across multiple generations: from teacher to student, and subsequently to student's student and so on. Our results provide new insights on drivers of creativity over the very long term, as well as the influence of teachers on students' achievements.

JEL Codes: I21, J24, N30, O31, Z11

Keywords: creativity, transmission of ideas, music history, teacher influence

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1 Introduction

What makes a great composer? One factor — not only relevant to the creative arts, but a broad range of areas — is education. There is long tradition of established music composers training new generations of composers, whether through one-on-one tutoring or formal education in music conservatories and other institutions. We explore the effect of this transmission of skills between composers: how does a composer's quality influence the quality of the composers he or she teaches?

We define composer quality in terms of reputation and legacy. Specifically, our measure of quality is based on biographies of music composers: the longer a given biography, the higher a composer's quality. We combine two data sources for this purpose. First, we source composer biographies from *Grove Music Online* 2016-2021, an authoritative compendium which chronicles the artistic careers of musicians through history. From Grove, we extract key identifying data (such as names, and dates and places of birth) as well as our central outcome variable: the word count of each composer biography. Second, we draw on Pfitzinger (2017), a musical genealogy which comprehensively maps the teachers and students of individual composers.

Taken together, our source material provides us with a set of 17,433 composers, of which 7,545 are recorded with biographies in Grove. Our dataset spans the globe, and includes composers born as far back as the sixth century.

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We identify 36,927 teacher–student pairs, and can link these across multiple generations — the longest single chain spans 21 generations, and up to 11,744 individual composers can be linked in one chain. The richness of our data and the unique historical context of music composers allows us to shed new light on skill and quality transmission over the very long term, including over multiple of generations.

The paper provides three interconnected explorations. First, we examine the correlation between composer quality and teaching activity. We show that higher quality composers in our dataset (that is, with longer biographies) are more likely to have taught other composers, with quality also correlated with the number of students a teacher has.

Second, and more importantly, we analyse how teachers' quality influences students' quality. We account for the effect of matching between teachers and students by comparing actual teacher–student pairs with counterfactual alternatives. Using a two-stage framework, we find that shared geographical characteristics — where composers were born — increase the likelihood of a teacher and a student connecting. Furthermore, we show that similarity of geographical characteristics between teacher and student serves to amplify quality transmission from teacher to student.

Third, we demonstrate the persistence of quality transmission across multiple generations. Not only do teachers influence the quality of their students, they also indirectly influence the quality of subsequent generations of students. When controlling for the individual attributes of the teacher, we identify a diminishing — but statistically significant — effect up to the eighth generation of student.

Our analysis links with an extensive body of research relating to musicians and music (e.g., Baumol and Baumol, 1994; Scherer, 2004; Borowiecki, 2017). From a cultural economics perspective, we contribute a novel and long-term view

on the drivers of creative talent. Furthermore, our work offers broader lessons in the context of education and human capital acquisition, contributing to a broad field of literature examining the role of teachers in shaping the gains from education for students (e.g., Chetty et al., 2014a, 2014b; Rivkin et al., 2005; Rockoff, 2004). Our approach aligns with other analyses of human capital, which have used biographies and publication metadata to measure educational returns (e.g., Waldinger, 2010; Simonton, 1984, 2004). Particularly related is a recent study by Borowiecki (2022), which shows how a sample of 341 composers influenced the style of work of their students. Our focus here is instead on the *transmission of skill and quality* across teacher-student relationships. We are also able to build on a considerably larger and longer data series, even if less detailed.

The paper is structured as follows: in section 2, we provide an overview of the related literature, and follow with a brief historical context of music education in section 3. We describe our source material in section 4, and discuss key features and trends of the data in section 5. Thereafter, we proceed with the results of our analysis. Section 6 explores what traits characterise a teacher, section 7 shows the results on how a composer's quality influences the quality of their students, and section 8 examines the long-term persistence of composer quality transmission across multiple generations. We conclude in section 9.

2 Literature review

The present study of music composers contributes to research on the determinants of creativity and, specifically, the transmission of culture. Baumol and Baumol (1994) consider the case of eighteenth-century Vienna, and find that demand for composers from competing noble courts served to cultivate a thriving market for composer talent. Scherer (2004) charts the shift in composer

careers over the course of the eighteenth and nineteenth centuries — away from fixed patronage in the service of noble courts toward freelance arrangements and private contracts. Oates and Baumol (1972) find that the commercial viability of the theatre in sixteenth- and seventeenth century London relied on low real wages, and that the lower production costs opened the door to more playwrights being able to establish themselves. Simonton (1975) considers the creative productivity of writers, and the role of age in influencing literary output. Similarly, Ginsburgh and Weyers (2006) examine the effect of age and experience on the creativity of painters across the life cycle. In the context of popular music, Askin and Mauskapf (2017) and Mueller (2021) show how new songs are inspired by old songs — that success depends on a combination of familiarity and differentiation.

Our research also relates to studies of human capital acquisition, and the contribution of teachers to students' outcomes (Angrist and Lavy, 2001; Bold et al., 2019; Bosshardt and Watts, 1990; Butters et al., 2011; Hanushek et al., 2019; Ost, 2014; Schober, 1984). A general finding is that student performance improves with teacher experience. Close analogues to our study consider the role of teaching and supervision in academic contexts, where the teacher–student relationship is relatively individualised. For example, Waldinger (2010) demonstrates the effect of faculty quality on the outcomes of PhD students, where quality is determined by publications and citations.

Methodologically, our use of biographical sources in measuring outcomes has a strong basis in other empirical applications. Borowiecki (2022) has previously demonstrated the applicability of biographical references in studying the stylistic influences of music composers. In contrast to that study, we consider the transmission of quality between composers and over the very long term. In different contexts, Borowiecki and Dahl (2021) and Kelly and O'Hagan (2007)

use biographies to study artistic clusters. Rasterhoff (2017) uses biographies to chart the historical development of Dutch painters and publishers, while Galenson (2002) uses art history texts to quantify the career success of a sample of French painters. (For further discussion on biography-based analysis methods, see Borowiecki and O'Hagan, 2012; O'Hagan and Kelly, 2005.)

Outside of creative domains, biographical information has been used to document growth in the educated elite (Dittmar and Meisenzahl, 2020), as well as to explore outcomes with respect to various professions, including academics (de la Croix et al., 2020), engineers (Hanlon, 2022), and lawyers (Hansen and Strømme, 2021). Similarly, metadata associated with published works has proven useful for several studies, including document file sizes as an indicator of the complexity of financial reports (Loughran and McDonald, 2014), citation counts of judgments as a measure of judicial performance (Landes and Posner, 1976; Murrell, 2021) and book types from copyright title pages to proxy for historic educational attainment (Rapone, 2022).

3 A brief history of music education

A comprehensive presentation of composer education over so many centuries and globally, is beyond the scope of this article. However, in what follows, we briefly outline some of the more important developments in music and music education.

The tradition of music education in Medieval Europe was centered at monasteries, cathedrals, and parish schools. This was the case for Francesco Landini, born in 1325 in Florence, who is one of the earliest composers covered in our data, for whom we know at least one of his teachers. Landini became a teacher and organist at the Florentine monastery of Santa Trinità in 1361, and at the church of San Lorenzo from 1365 onward.

Composers have been using increasingly sophisticated methods of writing music, such as the five-line staff. Developments in methods of writing music were important, as they made it possible to compose more complex works, including polyphonic compositions that characterize Western music beginning from the Renaissance. These inventions also meant that the ability to read and write music became increasingly valued, which in turn increased the importance of music education. The focus of early music education was initially on notation, and continued towards the study of composition for selected students (Mark, 2008).

An important role in the development of music education was played by Protestant Reformers who valued particularly the teaching of singing and instrumental music. As a result, the newly established schools included formal music education in their curricula from as early as the seventeenth century. At the elementary level, students learned music principles, and then progressed at the intermediate level to music theory and began composing music in class (Livingston, 1971). It was not uncommon that the most talented students would receive additional individual tuition.

During that time, the first important theories emerged of what constitutes the act of composing. Particularly influential were the writings of French composer Jean-Benjamin de Laborde, born in 1734 and with two teacher connections in our data. In Laborde's writing from 1780, a composition constitutes "the ordering and disposing of several sounds in such a manner that their succession pleases the ear." This definition comes very close to the notion of melody and has been regarded as accurate throughout most of history (Forte, 1974).

The golden age for classical music, at the turn of the nineteenth century, coincided with the emergence of conservatories across the world. The earliest conservatories were established in Naples already around the sixteenth century,

but it was not before the 1800s when education in conservatories has become available in most European cities. This represented not only a move toward secular music education, but also the formalization and institutionalization of music education. Over the nineteenth century, the European models of music education spread to the United States (Mark, 2008).

It was the individual teacher who played the predominant role throughout most of history in deciding upon the curriculum and instructional methods. However, since the second half of the twentieth century music education has become increasingly standardized. This coincides with a greater focus of scholarship on instructional methods and the development thereof (Costanza and Russell, 2017). Often, instructional methods of music education have been advanced by music composers, including Zoltan Kodaly (who had 58 students, according to Pfitzinger, 2017), Carl Orff (17 students), and Émile Jaques-Dalcroze (8 students).

Methods for the assessment of teaching have also developed, and became more widespread in the latter half of the twentieth century. This enabled performance of teachers and students to be tracked, and included criteria related to composing and arranging music within specified guidelines (Abril and Gault, 2016).

4 Data

We collect data from two sources: a large compendium listing teachers of composers provided by Pfitzinger (2017) and Grove Music Online, a leading encyclopedia of music and musicians. The data collection process is conducted in a planned, structured, and systematic way, and parts of it have been outlined in more detail in Borowiecki (2022).

4.1 Teacher-student connections

Data on teacher-student connections is collected from Pfitzinger (2017), who provides a vast compendium listing teachers and students of 17,460 composers in "Composer Genealogies, A Compendium of Composers, Their Teachers, and Their Students".

The reliability of this source has been carefully evaluated. In particular, it is important to observe that each musician listed by Pfitzinger (2017) has been a composer, as opposed to for example a music performer like a pianist. The aim to consider only composers becomes apparent from the title and also the preface: "*It is my hope that this book may serve as a resource for music historians, composers, and theorists who want to analyze the pedagogical influences of particular composers on their students. (...) there is a noticeable dearth of information about composers teaching composers and the importance of examining compositional lineage. (...) As writers and researchers examine the relationships of composers, they will be able to more readily access the composition teachers that a particular composer had, [and] who taught those teachers (...)*" (Pfitzinger, 2017, preface)

Borowiecki (2022) provides more extensive tests for a sample of composers listed by Pfitzinger (2017). It remains a possibility that Pfitzinger's list is biased in some ways, for example, towards American or more recent composers. However, such biases are not relevant for the aims of our paper. Potentially problematic would be a bias towards pairs of composers who have been particularly influential on one another. However, we do not see any reasons why this could be the case, especially since Pfitzinger does not observe the degree of influence between composers. Therefore, any eventual subjective choices made by Pfitzinger will not matter much for the interpretation of our results.

4.2 Composers and their quality

Additional data on music composers is scraped from *Grove Music Online* (Grove), a digital reference which builds on and continues the printed volumes of the *New Grove Dictionary of Music and Musicians*. Grove is regarded as a comprehensive encyclopedia providing extensive coverage of music and musicians. We have extracted information on the dates and places of composers' births and deaths. More importantly, Grove provides our measure of a composer's quality.

We define the quality of composers in terms of their reputation and cultural impact. The quality measures are expert-based metrics, approximated by the amount musicologists have written about a given composer. In contrast to more general biographical references, where biographies may focus on a range of personal and other aspects of individuals' lives, the focus of Grove is on the musical careers of individuals. All else being equal, a longer biography implies that a composer has had a more noteworthy career and attained a higher cultural impact.

The biographical entries in Grove contain different sections. Each biography include an overview of the composer's life. We refer to this section as "main description", as it is the substantive body of the biography. As figure 1 illustrates there is a positive correlation between the length of the main description sections for teachers and their students. All else being equal, a one per cent increase in teachers' word count is associated with a 0.1 per cent increase in a student's word count – a result that is statistically significant, and holds whether considering the average word count of each student's teachers or the maximum word count of the highest quality teacher of each student.

Interestingly, this result is different from Borowiecki (2022, Figure 2), who—based on a sample of top 341 composers—shows that there appears to be an insignificant relationship between quality of teachers and students. In this pa-

per, by building on a much bigger sample of more than 7,500 composers, the result of a positive correlation between teacher and student quality comes closer to what would be expected in a wider population.

[Insert Figure 1 here]

We also collect word count measures for additional sections in the biographies: the listing of composed works, the listing of written works (such as essays and books), and the biography's own bibliography. We refer to these sections respectively as "works", "writings" and "bibliography". Not every biography includes all these additional sections.

5 Descriptives

Our source material provides us with a set of 17,433 composers, of which 7,545 are recorded with biographies in Grove. The dataset is weighted strongly towards Western composers: composers born in the United States, Germany, Italy, England and France account for over half of all the composers in the dataset. Moreover, while the data include composers from as far back as the sixth century, our first teacher–student pairs arise with teachers born in the fourteenth century. The majority of composers in the dataset were born during the twentieth century.

[Insert Table 1 here]

As table 1 summarises, a noticeable trend is the rise of US composers. While 'old world' Europe accounted for the lion's share of our composers until the nineteenth century, the 'new world' of the United States dominates the more recent period. Overall, US composers account for just under a third of all observations in the dataset — by far, the largest country represented in the data — and almost all were born after 1800.

5.1 Biographies, word counts and quality

Our principal measure of quality is the word count of the body of the biography (main description). As table 2 outlines, the main description accounts for the substantive share of the total biographical content: on average, around 60 per cent for all biographies. By contrast, for those biographies which include a listing of composed works (around 80 per cent), the word count share for this section is on average less than 40 per cent.

[Insert Table 2 here]

A key trend to note in the biography data is how the average (main description) word count falls over time. The disaggregated results by time period for main description relate to the period in which composers were born. We do not suggest that the quality of composers has declined over time. Rather, one must account for the significant increase in the numbers of composers with biographies over time. Biographies for composers in the distant past are more likely to capture only a top tier for whom it was historically worthwhile writing about; as the costs of information recording and sharing have declined with time, the pool of composers for whom sufficient information exists for a biography has likely increased. One sign of this is the trend decline in the minimum word count.

5.2 Composer relationships

The bulk of composers are identified as students of other composers: 13,374 composers have known teachers (a further 373 are recorded as self-taught, with no other composer as teacher). Relatively fewer composers are identified as teachers of other composers — in total, 7,783. Figure 2 charts the distribution of students and teachers by birth year. As table 3 shows, the percentage share of composers who are teachers peaks at around 50 per cent for those born in the late eighteenth and nineteenth centuries.

[Insert Figure 2 here]

[Insert Table 3 here]

Students can have multiple teachers, just as teachers can have multiple students. Our data provide a total of 36,927 student–teacher pairs. As table 4 shows, and consistent with the rising number of composers over time, both the average number of teachers per student and the average number of students per teacher exhibit a trend increase. The sharp rise in the average number of students per teacher during the nineteenth century partly reflects the emergence of music conservatories and formal education settings for composers. There is no material difference in the average age gap between teacher and student over time. As discussed above, the average word count for composers declines over time. However, there is no discernible trend in the average gap between a student's word count and their teacher's word count. That the word count gap is consistently negative implies that, on average, students do not attain the same quality level as their teachers — here, one should recall that there are relatively fewer composers who become teachers. Finally, the share of student–teacher pairs where both student and teacher were born in the same country has declined since the seventeenth century. Overall, just over half of all pairs in our dataset were between composers born in the same country.

[Insert Table 4 here]

We can further link students and teachers across generations — that is, from teacher to student, to any student of that student, and so forth. Table 5 summarises how many generations of students and teachers, and how many composers across generations, can be linked in our dataset. We define student generations as the downstream relationship from a teacher through first, second and all subsequent generations of students. In the other direction, teacher generations run upstream from a student through all generations of teachers.

Panel A describes the average and range of generation 'chains' (that is, how many generations) for composers born in each time period. Panel B describes the average and range of the total number of composers that are linked across generations to composers born in each time period. Minimum values will always equal one, as the individual student or teacher is included as the first generation.

[Insert Table 5 here]

By way of example: on average, a composer born in the 1700's will be linked to five (5.1) generations of students, covering 2,091 composers. But they might have up to 17 generations of students, with as many as 11,362 individual composers. On average, that same composer will be linked to at least six (6.7) generations of teachers, covering 26.6 teachers. But they might have up to 15 generations and potentially 182 teachers.

All else being equal, the earlier a composer is born, the longer is their chain of student generations and the shorter is their chain of teacher generations. Moreover, counts of students will be greater than counts of teachers as there are more students than teachers in the dataset — and in turn, on average, more students per teacher than teachers per student.

6 Teacher attributes

As a first step to understanding how relationships between teachers and students emerge, it is useful to consider what attributes are characteristic of teachers. In the context of this study, our principal variable of interest is composers' biographical word counts. We hypothesise that the longer the biography — that is, the greater a composer's 'quality' — the more likely it is that a composer will have acted as teacher to another composer. We consider the lengths of different sections of the biographies. Most relevant is the section listing composers' written works: among other things, these writings include essays and texts on

music theory and history, which would be relevant in an educational context.

To assess the likelihood of a composer in our dataset being a teacher, we construct a probit model where the dependent variable is a binary response depending on whether a composer is a teacher or not. In addition to word count measures, we include variables for composers' lifespan and the number of contemporaneous composer births and deaths in the same city as the composer at their birth or death. We expect these factors to be positively correlated with the likelihood of being a teacher. We also include a full suite of controls for country of birth and half-century of birth.

The results are presented in table 6, and align with our expectations. Column one includes all word count measures (with effects measured per 100 words); the remaining columns test each biography section separately. The strongest effect is associated with the writings section (column 5), which is perhaps not very surprising, considering the fact that the writings section includes often teaching material written by a given composer. But this effect is also offset by the percentage share of the writings section relative to the total biography's word count. The interpretation of this result is that a composer is more likely to be a teacher in our dataset, the more written works the composer has produced — but only to the extent he or she still has a noteworthy musical career beyond those written works. A long list of written works matters less if the overall biography is short.

We can similarly examine how the factors considered above also influence how many students a composer has, given that she is a teacher. Table 7 reports ordinary least squares estimates, where the number of students is the dependent variable and the sample is restricted to only those composers who are teachers. Once again, we observe a significant effect associated with word counts, particularly when we focus on the writings section (column 5). Holding the section's

percentage share constant, a 100-word increase in the writings section is correlated with a teacher having four to five additional students. (One should recall here that the writings section is typically the shortest of the four biography sections, and relatively fewer biographies include composers' written works.)

[Insert Table 6 here]

[Insert Table 7 here]

While the number of contemporaneous births in a composer's city of birth matters more for the likelihood of being a teacher, contemporaneous deaths matter more for the number of students a teacher has. This is intuitively plausible: where one is born likely influences one's opportunities to form the necessary professional connections to get started, but as one relocates and builds a career, what matters more is where one ends up.

The results presented here should be interpreted as correlation indicators rather than causal effects. For our purposes, the exercise here is not to identify factors that influence whether a composer becomes a teacher. Rather, it is to identify composer traits observable in our dataset that are consistent with an increased likelihood of being a teacher. Thus, a longer biography — our proxy for composer quality — does not necessarily 'cause' a composer to become a teacher. It is also plausible that a composer's biography may be longer precisely because they have taught other composers.

As a further exploratory exercise, we consider the extent to which a teacher's composer quality influences the likelihood of his or her student having a biography. As students can have multiple teachers, we test the effect of both the average biographical word count across a given student's teachers and the maximum word count value for a given student's teachers (that is, each student's highest quality teacher). Table 8 presents results of probit models comparing both average and maximum teacher effects on the likelihood of a student having

a biography. We report the effects here for every 100 words in teachers' biographies, and control for effects from students' country of birth and time period. The effects are small in magnitude, but the positive correlation is statistically significant: students are more likely to be recorded in Grove, the higher the measured quality of their teachers is.

[Insert Table 8 here]

7 Teacher influence on student quality

7.1 The empirical setup

In this section, we introduce our econometric approach to evaluating the transmission of the teacher's quality on the student's quality. The simple regression may suffer from selection bias, as the more able students may tend to connect with the better teachers, just as the better teachers may select the better students. Therefore, we adopt a two-step procedure to take this into account.

First, we predict the probability of a teacher and a student forming a connection based solely on exogenous characteristics, namely geographical characteristics of the birth city of a composer. The collected data on actual teacher–student relationships is extended by the inclusion of potential connections, which we define for unconnected pairs of composers, who could have hypothetically been connected. We select composers who had at least one student and were alive at least one year when a candidate student was between the ages of 5 and 30. In principle, the student could have chosen any teacher from the reference group, but they chose different teacher(s).

Using this extended dataset, we estimate the following model:

$$PC_{ij} = \alpha + \gamma Geo_{ij} + \beta T_i + \nu_i + \mu_j + \epsilon \tag{1}$$

where PC_{ij} is equal to one for the connected pair of teacher i and student j and zero for the potential pair. Factors on the right-hand side are:

Geo_{ij} - set of commonality controls, such as shared country of origin, city of birth, and nationality of teacher i and student j[1]

T_i - set of half-century dummies

ν_i - teacher fixed effects

μ_j - student fixed effect.

We then weight the teacher's quality by the estimated probability of connection. A connection is less likely where the student must move away from the home city, facing additional financial costs, as well as costs in terms of lost social connections and adaptation. Additionally, connecting to teachers from different cultural background might lead to a less efficient quality transmission than connecting to a teacher of the same background in terms of nationality or country of origin. For example, the Polish student might grasp more information and skills from the Polish teacher even if they meet outside Poland than from the foreign teacher due to language barriers or cultural differences.

All else being equal, two teachers of the same quality will transfer different quality to a student dependent on their geographic and cultural proximity. 'Effective' quality of the teacher will be lower due to the above-mentioned additional costs.

We use the estimated probability of connection as a discount rate on the quality of the teacher. The higher the expected probability of the connection, the higher we expect the 'effective' quality to be.

[1]For the robustness check, we also repeated the analysis with the geographical distance between teachers' and students' cities of birth, which provided similar results (see Tables A.1 and A.2 in Appendix). However, it was not possible to determine the coordinates of all the cities in our dataset, due to the presence of smaller cities with the same names, and cities that changed names, which resulted in much smaller sample.

Thus, on the second step we estimate the following model:

$$Q_j = \alpha_2 + \beta_2 P\hat{C}_{ij} * Q_i + \theta_2 X_j + \gamma_2 T_j + \nu_i + \epsilon \tag{2}$$

where Q_i and Q_j are the quality measures of teacher i and student j correspondingly. X_j represents the set of controls, such as shared country of origin, city of birth, and nationality of student j, as well as the total number of teachers.

7.2 The results

Table 9 presents the estimation results of model (1).[2] We can observe that the birth proximity of the student and the teacher positively affect the probability of being connected, as expected.[3] The magnitude of this effect is rather small, however, the dependent variable from the expanded dataset used at the first step is rather sparse, with many zeros for potential connections that did not happen.

[Insert Table 9 here]

The results are consistent for the models with different sets of fixed effects. We take the results from the model with both teachers and students fixed effect as the estimated probability of connection between student and the teacher for the estimation of model (2) at the second step. Both types of fixed effects will allow to capture the possible unobservables in networking behaviour.

Table 10 presents the estimation results of the second step. Columns (1) and (2) provide the results for the model 2 when each pair is treated separately.

[2]The estimations presented in this section were conducted on a cloud computing facility of the Vienna University of Economics and Business. The external big computer and its high computing power was required given the size of our extended dataset, which includes about ten million observations.

[3]Note that predicted probability is on average 0.44 percent, whereas the true rate of connectedness in this extended dataset is 0.45 percent. The t-test suggests equal means. The histogram of differences between the true and predicted probability of connection is concentrated around zero. When only the sample of true connections is considered, the estimated probability of connection is significantly larger at 0.05.

In this estimation approach, we might have several observations for the same student with more than one teacher; however, their quality stays constant, so we are not able to control for the student's fixed effects that could affect quality. Therefore we also propose an alternative second step, with average per student 'effective' quality of the teachers. The results for the alternative estimation are presented in columns (3) and (4).

In both specifications, we observe that the teacher's quality is positively transmitted to the student's quality. Other things equal, the students with a similar probability to connect to teachers will benefit more from the high quality teacher. Likewise, the students with teachers of similar quality will benefit more if they are more likely to connect to the teacher, i.e. they are closer to the teacher geographically. The geographical differences can be seen as a sort of discount factors on the teacher's quality.

A teacher with one percent more words in the main Grove entry will increase the number of words in the main Grove entry of the student by 0.25 percent discounted by the estimated probability to connect with the teacher. Considering the average probability to connect of about 0.05, the result implies a 0.13% increase in students quality due to a 10% higher teacher quality.

[Insert Table 10 here]

8 Multigenerational analysis

We have observed previously that a teacher's quality may determine the quality of her student. Therefore, it is pertinent to ask whether the teacher's influence on the quality of a student persists into the next generation, when the student becomes a teacher herself? To put it differently, does there exist a relationship between a teacher's quality and the quality of her student's student? The unique long-term feature of our dataset allows us to investigate the persistence of quality

across generations of students.

Extending our data beyond the 36,927 first-degree connections, we arrive at 36,364 second-degree, 34,852 third-degree, and later 9,609 tenth-degree connections. The data is then used in a model with or without teacher fixed effects, as presented in table 11. The findings confirm that teacher's quality plays a large and significant role for the first generation of students, as shown previously. Moreover, the persistence in quality remains significant and large through several subsequent generations in a composer's musical lineage before it starts to fade. In particular, the coefficients remain positive and statistically significant into the eight generation in the model with teacher fixed effects in column 2 of table 11 but the point estimates decrease gradually. For example, teachers with biographies longer by 10 percent have students whose biographies are longer by about 0.9 percent.

The results shown here support the notion that quality is persistent across multiple generations, suggesting a remarkable path dependency when it comes to the quality of a composer. This finding is of relevance to the literature on the intergenerational transmission of traits and it is in line with recent scholarship on social immobility by disclosing in a different context how persistent can be quality traits across many generations.

Additionally, our intergenerational results offer an alternative way to address concerns about endogeneity. While the pairing of teachers and students likely reflects active choices on the part of one or both parties (a student choosing an acclaimed teacher, or a teacher choosing a promising student), there is no reason to presume that the same applies to the link between a teacher and, say, a fifth-generation student. That is, for later generations, the observed effect of a teacher's quality can credibly be interpreted as causal.

[Insert Table 11 here]

9 Conclusion

The central insight that this paper builds on is that teacher quality matters for student performance. The purpose has been to quantify the extent of quality transmission between music composers, where quality is defined in terms of reputation and cultural impact. By focusing on composers, we are able to illustrate the effect of professional creatives communicating their field-specific skills and talents to new generations.

Our analysis is directly relevant to understanding the long-term development of music composers and other fields in the cultural and creative sectors with similar patterns of within-field training. The results also have broader applicability with respect to the acquisition of human capital. In particular, our findings highlight two complementary factors relevant for students' educational attainment: first, how accomplished a student's teachers are; second, how compatible student and teacher are in terms of their backgrounds. To the extent that students and teachers share common cultural factors — perhaps most obviously, the same language — this amplifies the transmission of quality from teachers to students. Put simply, our results show it is easier for students to absorb the talents of their teachers if they have similar backgrounds.

Our most striking finding is the persistence of quality transmission. While the effect of a teacher's quality is most pronounced on the quality of that teacher's direct students, our results reveal cascading effects that persist through several generations. For example, when controlling for individual teacher effects, we find that a significant positive correlation between teacher quality and the observed quality of up to the eighth generation of students.

That said, we would caution against over-generalising our results. The pattern of education among composers is distinct from schooling. Our study focuses on teachers' quality with respect to their own careers as composers. This is dis-

tinct from teachers' pedagogical quality: that is, their mastery of teaching rather than their mastery of the content. Our data do not allow us to directly observe differences in composers' pedagogical attributes. Nevertheless, while the rise of music conservatories during the nineteenth century represents a change in the dynamics of the teacher-student relationship — reflected, for example, in the increase in the average number of students per teacher — we note that the effect of quality transmission holds over the long term.

At least two concerns may be raised with respect to our data: one, the extent to which word count is a true proxy for quality; two, the risk of bias with respect to which composers are included in our biographical source material. On the first point, any assessment of quality is necessarily subjective: beauty is in the eye of the beholder. We have nevertheless sought an objective basis to define quality. Given our focus on reputation and cultural impact, we consider biographical word count to be a fair indicator of quality. But were one to consider quality through a different lens — for example, by attempting assessment of the technical competence of composers or the complexity of their compositions — then different measures (and source material) would be required.

On the second point, while we accept that bias can be found, one must ask if and how such bias would affect our results. One bias relates to the geographic distribution of the composers in our dataset. We acknowledge there is a heavy weighting of European and US composers, which is likely disproportionate in the context of global music history. In the most restrictive sense, one can conclude that we find quality transmission among *Western* composers. But while the magnitude of effects might conceivably differ, we would not expect that the nature of creative quality transmission is so fundamentally different for composers in other parts of world that are less represented in our dataset.

While our results confirm the presence of quality transmission, we do not

draw any definitive conclusions about the mechanisms of quality transmission or why quality effects evidently persist. An obvious story is that if teacher quality influences student quality, that when a student becomes a teacher, some element of the quality they pass on to their students is an echo of their own teachers. But how and why this occurs is less clear.

One factor may be the effect of the small number of highly accomplished composers whose contributions to the world of music are so profound, that there are reputational gains for the successive generations of students who follow in their footsteps. While imitation may be the sincerest form of flattery, it may also yield considerable career benefits to more effective imitators — and the best placed to imitate are likely to be student descendants of the original article. This proposition is in line with Borowiecki (2022), who shows that imitating to a greater extent high quality teachers may be conducive towards one's successful career.

Similarly, high quality composers may be better at gently guiding — or forcefully directing — their prodigies to professional success by harnessing the lessons of their own achievements. A further possible explanation relates to nepotism and access to influential networks: that is, part of the effect we observe is less about *what* students know and more about *who* they know. It is not unlikely that there exists some degree of nepotism in music education as it is known to occur in parent-child relationships (de la Croix and Goñi, 2021). Disentangling the relative strength of these — and potentially other — channels is beyond the scope of this paper. There is undoubtedly a wealth of opportunities for deeper explorations on these points.

There is also little doubt that the historical music setting of this paper is highly distinct. However, the results presented and mechanisms outlined above would likely apply to other creative domains in the past and even nowadays.

Therefore, we can perhaps conclude by venturing into the question: What can musicians, other artists or even creative workers in the cultural and creative sectors take away from our findings? For the aspiring creative person, the obvious lesson is that it helps to find an accomplished teacher. Better still, find an accomplished teacher with a similar cultural background. While there are no guarantees of success in life, the chances of being recognised as a high-quality creative person are stronger with a high-quality teacher.

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10 Tables

Table 1: Top 10 countries for composer births, percentage shares

Country	Total (%)	(N)	Pre 1500	1500-99	1600-99	1700-99	1800-99	1900-49	1950-
USA	31.9	5564		1		2.8	13	43.9	57.3
Germany	10.7	1871	16.8	18.8	26.8	28.9	17	4.9	3.1
Italy	7.5	1307	16	36.9	35.2	18.5	8.4	2.8	2.8
England	6.2	1088	14.3	13	7.3	8.4	8	4.7	5
France	5.9	1030	19.3	7.6	15.7	11.8	9.1	3.3	2.2
Austria	2.5	444	1.7		1.1	6.8	4.7	1.5	.7
Russia	2.5	432			.2	.9	4.3	2.8	1
Czechia	2.3	401	.8	.2	2.3	6.8	3.3	2	.3
Spain	2	346	5.9	7.3	3.2	2.4	3	1.1	1.2
Belgium	1.9	325	13.4	6.8	2.5	2.5	3.3	1	.3
Europe	57.1	9958	99.2	98.8	99.1	96.8	81.5	42.4	26.1
Rest of world	42	7315	.8	1.2	.7	3.2	18.4	57.5	73.8
Total (N)		17433	119	409	559	1327	4735	6503	3586

Notes: Percentage totals calculated relative to total number of births in each time period. For a small number of composers, birth countries are not identified. Hence, percentage shares do not sum to 100.

Table 2: Summary statistics: Biographical word count

Type / period born	N	Mean	Median	Min	Max	Share
Main description	7545	660.2	300	15	42011	58.6
Pre 1500	106	1998.2	957.5	211	22721	62.3
1500-99	386	1029.4	592.5	78	16847	65.9
1600-99	513	1087.8	532	67	39533	63.8
1700-99	1053	814.4	389	15	42011	61.9
1800-99	2428	711.6	280.5	16	29997	63.3
1900-49	2645	415.3	266	21	19447	51.8
1950-	384	308.4	238	113	3281	51.4
List of composed works	6108	478.8	247	13	46397	36.7
List of written works	1462	98.1	58	5	1616	9.8
Bibliography	6185	180.8	70	3	16402	11.9
All sections	7545	1215	576	15	92595	

Notes: Share column reports each section's average percentage share of the total word count across the four biography sections. Calculations for each section are based only on those observations which include the relevant section. Hence, the word count shares for the four sections do not sum to 100.

Table 3: Share of composers who are teachers, by time period

	Composers (N)	Teachers (N)	Teachers (%)
Pre 1500	122	28	23
1500–49	151	49	32.5
1550–99	265	80	30.2
1600–49	216	95	44
1650–99	349	155	44.4
1700–49	536	253	47.2
1750–99	796	415	52.1
1800–49	1527	792	51.9
1850–99	3219	1603	49.8
1900–49	6503	2930	45.1
1950–99	3616	1293	35.8
2000-	16	2	12.5
Total	17433	7783	44.6

Notes: Total row includes composers for whom no birth year is available in our dataset.

Table 4: Summary statistics: student-teacher pairs

Period	Average number of teachers per student	Average number of students per teacher	Average difference in year born (S-T)	Average word count (main description)	Average word count difference (S-T)	Percent of ST pairs born in same country
Pre 1500	1.0	1.6	28.6	1998.2	-4948.3	39.1
1500-99	1.2	1.6	25.4	1029.4	-589.4	72.2
1600-99	1.4	2.0	25.8	1087.8	-1202.5	80.4
1700-99	1.6	3.0	28.1	814.4	-1863.0	60.9
1800-99	2.0	4.6	26.7	711.6	-1319.5	50.1
1900-49	2.5	5.4	24.9	415.3	-1275.7	51.3
1950-	2.8	3.5	25.8	308.4	-894.3	50.6
Full sample	2.2	4.3	25.8	660.2	-1307.8	52.8
	(1.4)	(8.1)	(13.1)	(1731.0)	(4630.8)	

Notes: Standard deviation for averages (full sample) denoted in parentheses.

Table 5: Summary statistics: generations of composers over time

	Student generations				Teacher generations			
	Mean	Median	Min	Max	Mean	Median	Min	Max
	Panel A: Number of generations of composers							
Pre 1500	2.9	2	1	21	2.2	2	1	4
1500-99	3.4	2	1	19	2.9	2	1	6
1600-99	5.3	2	1	19	4	3	1	11
1700-99	5.1	2	1	17	6.7	7	1	15
1800-99	3.5	2	1	14	12	14	1	20
1900-49	2.1	1	1	10	14.5	15	1	21
1950-	1.5	1	1	8	15.2	16	1	19
Full sample	2.7	2	1	21	13.2	15	1	21
	Panel B: Number of composers across linked generations							
Pre 1500	515.3	2	1	11025	2.3	2	1	4
1500-99	1032.8	2	1	11471	3.5	3	1	11
1600-99	2534.1	2	1	11744	6.9	5	1	33
1700-99	2091	2	1	11362	26.6	18	1	182
1800-99	403.4	2	1	8679	175.4	188	1	583
1900-49	21.2	1	1	2553	456.2	449	1	1118
1950-	2.7	1	1	122	828.7	856	1	1557
Full sample	343.7	2	1	11744	471.1	410	1	1557

Notes: This table summarizes how many generations of students and teachers, and how many composers across generations, can be linked in our dataset. Panel A describes the average and range of generation "chains", while Panel B describes the average and range of total number of composers that are linked across generations. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: The quality background of a composer teacher

	(1)	(2)	(3)	(4)	(5)
	Probability that composer is a teacher				
Word count (main description)	0.012***	0.024***			
	(0.004)	(0.002)			
Word count (works)	0.021***		0.044***		
	(0.005)		(0.003)		
Word count (bibliography)	0.003			0.108***	
	(0.015)			(0.009)	
Word count (writings)	0.280***				0.456***
	(0.055)				(0.052)
Main pct of total		-0.003***			
		(0.001)			
Works pct of total	-0.001		-0.004***		
	(0.001)		(0.001)		
Bibliography pct of total	0.001			-0.007***	
	(0.002)			(0.002)	
Writings pct of total	-0.011**				-0.024***
	(0.005)				(0.004)
Lifespan	0.037***	0.038***	0.037***	0.037***	0.036***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Lifespan × Lifespan	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Births (per 100)	0.030***	0.029***	0.031***	0.030***	0.031***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Deaths (per 100)	0.027	0.029	0.025	0.023	0.034
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Country FE	Yes	Yes	Yes	Yes	Yes
Half Century FE	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.074	0.068	0.067	0.065	0.053
Observations	7468	7468	7468	7468	7468

Notes: The dependent variable is the probability of a composer being a teacher, and it is regressed in a Probit model on word count measures of different parts of a composer's biography and various background characteristics. Births/deaths (per 100): the number of composer births/deaths in the composer's country of birth/death in the half-century (00-49 or 50-99) of their birth/death. Word count (all types): Effect per 100 words. In column 1, "main pct of total" is omitted due to multicollinearity: the percentage shares of all four sections sum to 100. Standard errors are reported in parentheses.

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Number of students of composer teachers and teacher quality

	(1)	(2)	(3)	(4)	(5)
	Number of students of a teacher				
Word count (main description)	0.190***	0.111***			
	(0.024)	(0.011)			
Word count (works)	0.067***		0.137***		
	(0.023)		(0.016)		
Word count (bibliography)	-0.423***			0.161***	
	(0.057)			(0.027)	
Word count (writings)	3.309***				4.329***
	(0.390)				(0.365)
Main pct of total		-0.046***			
		(0.014)			
Works pct of total	0.036**		0.006		
	(0.015)		(0.014)		
Bibliography pct of total	0.147***			0.056	
	(0.038)			(0.037)	
Writings pct of total	-0.240***				-0.360***
	(0.051)				(0.049)
Lifespan	-0.083	-0.101	-0.101	-0.121	-0.129
	(0.118)	(0.120)	(0.121)	(0.122)	(0.120)
Lifespan × Lifespan	0.002*	0.002**	0.002**	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Births (per 100)	0.160**	0.148**	0.163**	0.157**	0.164**
	(0.070)	(0.071)	(0.071)	(0.072)	(0.071)
Deaths (per 100)	2.179***	2.241***	2.292***	2.274***	2.166***
	(0.351)	(0.356)	(0.358)	(0.360)	(0.356)
Country FE	Yes	Yes	Yes	Yes	Yes
Half Century FE	Yes	Yes	Yes	Yes	Yes
R^2	0.155	0.126	0.115	0.107	0.129
Observations	3780	3780	3780	3780	3780

Notes: This table summarizes OLS estimates for factors correlated with the number of students per teacher. The dependent variable is the number of students of a teacher and the sample is restricted to composers who are teachers. Births/deaths (per 100): the number of births/deaths in the composer's country of birth/death in the half-century (00-49 or 50-99) of their birth/death. Word count: Effect per 100 words. In column 1, "main pct of total" is omitted due to multicollinearity: the percentage shares of all four sections sum to 100. Standard errors are reported in parentheses.

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: The role of teacher quality on students having a biography

	All teachers		Only teachers with biographies	
	Average	Maximum	Average	Maximum
Probit results				
Teacher word count	0.00185***	0.00263***	0.00124***	0.00225***
	(0.00046)	(0.00029)	(0.00041)	(0.00029)
Country FE	Yes	Yes	Yes	Yes
Half Century FE	Yes	Yes	Yes	Yes
Pseudo R^2	0.194	0.198	0.178	0.181
Observations	13269	13269	11694	11694

Notes: This table reports the estimates from a Probit model where the dependent variable is a dummy-variable equal to one if a student has a biography and zero otherwise. Teacher word count concerns either average or maximum teacher word count (see column heading), per 100 words in main description. Standard errors are reported in parentheses.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Probability of teacher-student connections

	(1)	(2)	(3)
	Probability of connection		
Same country of origin	0.0109***	0.0106***	0.0110***
	(0.000282)	(0.000274)	(0.000283)
Same nationality	0.0214***	0.0211***	0.0243***
	(0.000263)	(0.000253)	(0.000277)
Same city of birth	0.0433***	0.0420***	0.0404***
	(0.00129)	(0.00128)	(0.00127)
Half Century FE	X	X	X
Student FE	X		X
Teacher FE		X	X
Observations	9882603	9882603	9882603
R^2	0.022	0.043	0.047

Notes: This table reports estimates of equation (1). The dependent variable is a dummy-variable equal to 1 if a teacher-student combination is connected and zero otherwise. Standard errors are reported in parentheses.

Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: Effect of teacher's expected quality on the student's quality

	(1)	(2)	(3)	(4)
	Student quality (logged word count)			
Estimated probability of connection *	0.252***	0.313***		
teacher quality (logged word count)	(0.0609)	(0.0371)		
Estimated probability of connection *			0.200**	0.151***
teacher quality (logged word count)			(0.0979)	(0.0559)
(average per student)				
Number of teachers	0.174***	0.0708***	0.0777***	0.0743***
	(0.00490)	(0.00245)	(0.0114)	(0.00809)
Same country of origin	0.125***			
	(0.0230)			
Same nationality	0.0369			
	(0.0249)			
Same city of birth	-0.0745*			
	(0.0397)			
Same city of death	-0.0109			
	(0.0199)			
Student is born in the teacher's city of death	-0.0449*			
	(0.0230)			
Half Century FE	X	X	X	X
Teacher FE	X	X	X	
Observations	26404	43932	5070	5070
R^2	0.400	0.365	0.488	0.126

Notes: This table reports estimates of equation (2). The dependent variable is student quality and is measured in the log number of words in the main part of Groove encyclopedia. Standard errors are reported in the parentheses.

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

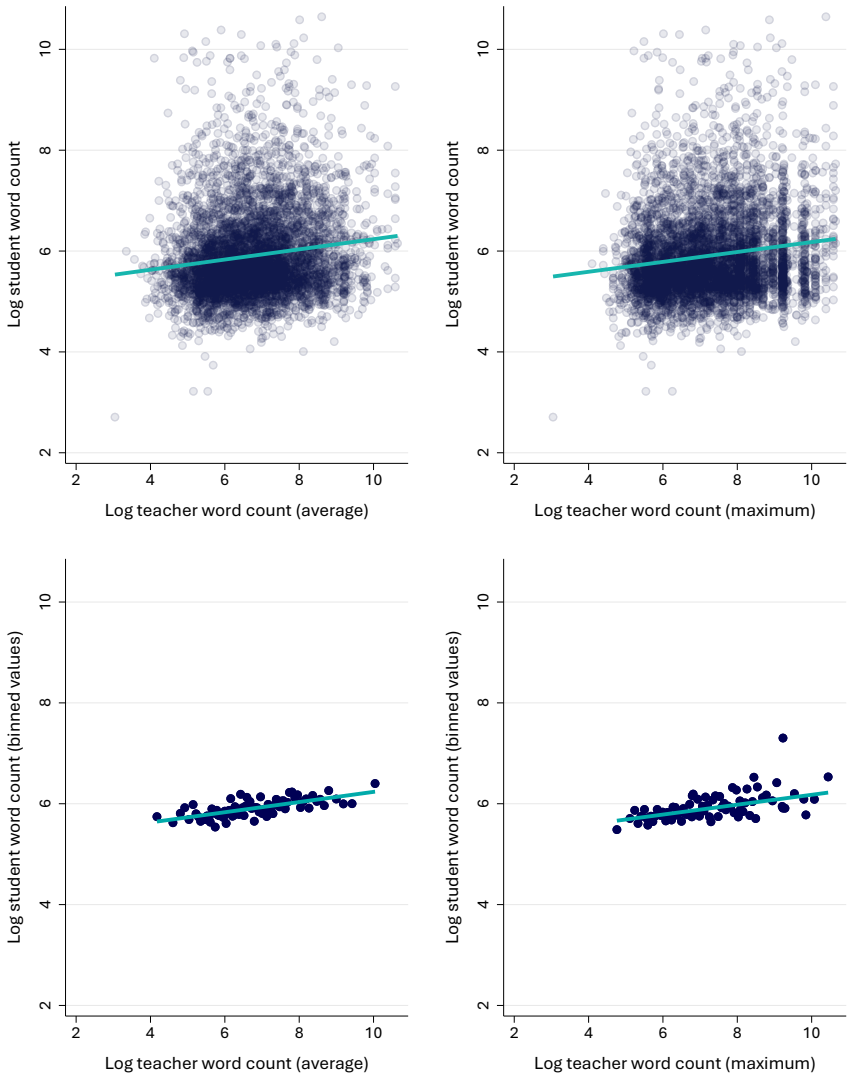
Table 11: Multigenerational transmission

	(1)	(2)
	Student quality (logged word count)	
Teacher quality (logged word count):		
1st degree	0.0169***	0.0886***
	(0.00143)	(0.00311)
2nd degree	0.0109***	0.0682***
	(0.00147)	(0.00302)
3rd degree	0.00929***	0.0541***
	(0.00153)	(0.00299)
4th degree	0.00565***	0.0420***
	(0.00158)	(0.00297)
5th degree	0.00262	0.0311***
	(0.00167)	(0.00296)
6th degree	0.00109	0.0219***
	(0.00179)	(0.00297)
7th degree	0.0000125	0.0144***
	(0.00183)	(0.00296)
8th degree	-0.00114	0.00868***
	(0.00197)	(0.00298)
9th degree	-0.00261	0.00325
	(0.00214)	(0.00306)
10th degree	-0.00358	
	(0.00254)	
Observations	81,612	81,612
R^2	0.003	0.020
Teacher FE		X
Sample	Full	Full

Notes: The dependent variable is student quality calculated as the logged word count length of the biographical entry. Teacher quality is measured as the logged word count length of the biographical entry of the 1st degree teacher, 2nd degree teacher, etc. Standard errors are reported in the parentheses.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

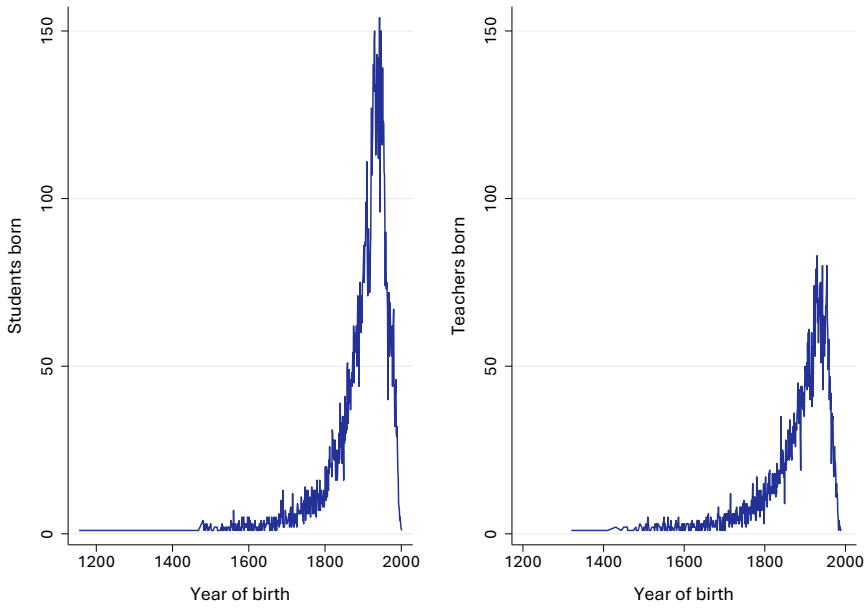
11 Figures

Figure 1: Correlation between teacher and student quality



Notes: Composer quality is approximated with the word count in the main description of the biographical entry. The plots in the top panels are based on all observations, while the plots in the lower panels are based on binned observations. The plots in the panels to the left are based on the average word count, while the plots in the panels to the right are based on the value of the highest quality teacher, if there was more than one teacher.

Figure 2: Student and teacher births by year



A Additional Tables

Table A.1: Probability of connection based on distance at birth and fixed effects

	(1)	(2)	(3)
	Probability of connection		
Distance between cities of birth	-0.000000961***	-0.000000727***	-0.00000141***
	(1.05e-08)	(1.27e-08)	(2.22e-08)
Half Century Dummies	X	X	X
Student FE	X		X
Teacher FE		X	X
Observations	4184462	4184462	4184462
R^2	0.009	0.030	0.036

Notes: Standard errors in parentheses.
Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.2: Effect of teacher's expected quality on the student's quality, with distances as instrument

	(1)	(2)	(3)	(4)
	Student quality (logged word count)			
Estimated probability of connection * teacher quality (logged word count)	0.227***	0.309***		
	(0.0421)	(0.0616)		
Estimated probability of connection * teacher quality (logged word count) (average per student)			0.217*	0.130**
			(0.131)	(0.0544)
Number of teachers	0.184***	0.0688***	0.0883***	0.0789***
	(0.00801)	(0.00375)	(0.0175)	(0.0105)
Same country of origin	0.225***			
	(0.0370)			
Same nationality	-0.0488			
	(0.0346)			
Same city of birth	0.0312			
	(0.0457)			
Same city of death	-0.0552*			
	(0.0309)			
Student is born in the teacher's city of death	-0.0507*			
	(0.0361)			
Half Century Dummies	X	X	X	X
Teacher FE	X	X	X	
Observations	10968	20428	2887	2887
R^2	0.437	0.412	0.557	0.127

Notes: Quality is measured in the number of words in the main part of Groove encyclopedia. Standard errors are reported in the parentheses.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

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