IES Institute of Education Sciences

Exploring Teachers' Influence on Student Success in an Online Biology Course

Regional Educational Laboratory Southeast

At Florida State University

REL 2021–056
U.S. DEPARTMENT OF EDUCATION

A Publication of the National Center for Education Evaluation and Regional Assistance at IES

Exploring Teachers' Influence on Student Success in an Online Biology Course

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January 2021

Instruction plays a critical role in student success. However, most studies of teachers' effects on student learning focus on face-to-face settings. Some aspects of online courses, such as the choice of synchronous or asynchronous instruction and the course structure, might reduce teachers' influence on their students. This study of an online high school biology course offered by Florida Virtual School examined the variation in students' course segment (similar to semester) completion rates, end-of-segment exam scores, and time to segment completion that is attributable to the influence of teachers. Students' scores on the end-of-segment exam varied only slightly across teachers, while completion rates and time to completion varied more.

Why this study?

The 2020 Covid-19 pandemic has turned a spotlight on K–12 virtual-space learning. In the United States many school districts switched from in-person teaching to remote learning, in which students and teachers work together synchronously in the virtual space for a large part of the students' learning time (see box 1 for definitions of key terms). This model attempts to directly replicate in the virtual school space many of the teacher–student interactions that occur in the traditional school space. However, other online learning programs differ from this model in significant ways, mainly by allowing students to spend much of their time with virtual course materials asynchronously. This study began before the pandemic and focuses on online learning in a school with asynchronous instruction.

Prior to the Covid-19 pandemic, the growing popularity of online instruction prompted questions about teachers' influence on student success. Leaders of Florida Virtual School, one of the largest virtual school networks in the nation, observed that some teachers had consistently better outcomes for students in their online classes. The school leaders asked the Regional Educational Laboratory Southeast to help identify teaching practices that might be associated with better student outcomes. Their goal was to identify promising practices for further investigation and eventually to encourage teachers to adopt the practices that proved more effective. If a practice was related to improved outcomes, Florida Virtual School staff planned to incorporate it into their teacher training program.

Teachers' instructional practices can directly affect student outcomes. Prior studies on teacher effectiveness in different grades and subjects, most commonly reading and math, have found varying results (for summaries, see Nye et al., 2004; Schochet & Chiang, 2010). For example, across different cohorts and elementary school grades, one study reported classroom effect sizes on students' achievement of 0.21 to 0.42 (Rowan et al. (2002). In contrast, another study found much smaller teacher effect sizes of 0.10 in reading and 0.11 in math across grades 3–7 (Rivkin et al., 2005). In short, research agrees that teachers influence student outcomes, but the size of the impact can vary considerably depending on the context.

Research has focused primarily on face-to-face instruction (Nye et al., 2004; Rivkin et al., 2005; Rockoff, 2004; Rowan et al., 2002; Schochet & Chiang, 2010). Less is known about the influence of teachers on student outcomes in online settings, despite the rising popularity of online instruction. Although studies find that teachers in an online environment can provide caring support to students (Borup et al., 2013; Drysdale et al., 2014; Velasquez, Graham, & Osguthorpe, 2013; Velasquez, Graham, & West, 2013), research has been limited on the influence of online

For additional information, including background on the study, technical methods, and supporting analyses, see the appendices for the report on the Institute of Education Sciences website.

Box 1. Key terms

Asynchronous and synchronous instruction. In asynchronous instruction teachers and students interact virtually with a time delay, whereas in synchronous instruction teachers and students interact virtually in real time.

Between-teacher and within-teacher variance. This study examined the extent to which student outcomes for segment 1 (see below) of an online biology course were different with different teachers. That is, do students of some teachers have better or worse outcomes than students of other teachers? This difference is referred to as "between-teacher" variance because it measures how much student outcomes differ across teachers. Within-teacher variance is the extent to which student outcomes differ for students of the same teacher. If between-teacher variance of an outcome is large and within-teacher variance is small, that suggests that students of the same teacher are similar for a given outcome. For example, this might mean that most of the students of the same teacher performed similarly on a test. If the between-teacher variance is low and within-teacher variance is large, that suggests that the same teacher's students vary on a given outcome. For example, the students of the same teacher might have a wide range of scores, from low to high.

Effect size. Difference that would be found between two students who were assigned to teachers who are one standard deviation apart in the teacher distribution of average outcomes.

End-of-segment exam. A cumulative exam developed by Florida Virtual School and given at the end of each segment of a course. The exam is a computer-graded, short-answer test covering all modules (see below) of the segment. End-of-segment exams are scored on a separate scale for students in honors classes and those in nonhonors classes. To create a common metric, all scores are reported as the percentage of questions answered correctly (0–100).[1]

Segment. A self-contained portion of a course. Florida Virtual School divides courses into segments, which are analogous to semesters, except that segments do not have specific start and end dates. Segments consist of modules, with an exam at the end of each module. Students complete each module at their own pace. The biology course examined for this study has two segments. Segment 1 results are discussed in the main report. Segment 2 results are discussed in appendix B.

Segment completion. Student completion of segment 1 of a course, defined as having taken the end-of-segment exam. Students who withdraw from a course before taking the end-of-segment exam (regardless of their grade at the time) are not considered to have completed the segment. Students can withdraw at any time before taking the exam. By contrast, students who take the end-of-segment exam but fail the segment are still considered to have completed the segment.

Time to segment completion. The number of weeks a student takes to complete segment 1 of the biology course examined in the study.

Note

1. The study team tested a model that controlled for honors/nonhonors status and found that including or excluding honors/nonhonors status in the model did not affect the results (see table B4 in appendix B).

teachers on student outcomes, including whether the teaching modality, such as instruction in real time, affects the degree of teacher influence.

The modality of online instruction can vary considerably, and the differences can alter the influence that teachers have on student outcomes (Borup et al., 2018, 2019). Online courses can be conducted synchronously (in real time), such as with live video; asynchronously, in which students and teachers interact virtually with a time delay; or in a combination of synchronous and asynchronous instruction. Courses might have both an online teacher and a face-to-face facilitator (Borup et al., 2019). When teachers and students are separated over space or time, they might find it more difficult to establish a personal relationship (Hawkins et al., 2012). Consequently, the influence of teachers on students' engagement and academic achievement can vary based on the online modality (Lei et al., 2018).

Relatedly, some online courses are highly prescriptive, which might lessen the influence of online teachers on student outcomes. In prescriptive online courses, teachers who teach the same course use the same materials,

assignments, and assessments, many of which are computer graded (Barbour, 2013). This highly structured environment differs from many face-to-face settings, where teachers create their own tests and assignments. By reducing the variation in teachers' instructional practices, highly structured online courses may also reduce differences in student performance across teachers compared with face-to-face instruction.

Determining the influence of teachers on students' course outcomes requires separating the influence of differences in teachers' instruction from the influence of differences in students based on demographic characteristics, prior knowledge, motivation, and skills. The analyses in this study looked at the total variation across students' course outcomes and attributed it to either differences between teachers (between-teacher variance) or differences between students (within-teacher variance).

Florida Virtual School requested that this study focus on a course that has an annual statewide assessment and that is part of the state's accountability system. Qualifying courses include Algebra I and II, biology, civics, English language arts, geometry, and history. Florida Virtual School staff selected the biology course as the focus of the study.

Because of the large size of Florida Virtual School and the way students are assigned to teachers, the school offers an excellent opportunity to study teachers' influence. In 2017/18 Florida Virtual School served more than 200,000 students (Florida Virtual School, 2018). Many courses are taught by a large number of teachers, who are assigned to students using a computer-developed algorithm. Student characteristics, such as demographic background and academic achievement, do not factor into the assignment of students to teachers.[1] As a result, students' ability levels can be expected to be random across teachers. This random assignment of students makes the school a good candidate for a study of online teachers' influence.

Florida Virtual School follows a highly prescriptive approach, with all students and teachers sharing the same curriculum, instructional materials, and exams. The exams are generally a combination of computer-graded multiple-choice questions and teacher-graded open-ended questions. The primary coursework is completed asynchronously, although teachers can direct students to additional instructional sessions conducted in real time via an online application such as Blackboard. The results of this study would thus be most relevant for courses taught using a similar model.

Research questions

This study estimated the amount of variation in student outcomes in Florida Virtual School's online biology course that was associated with teachers. It focused on students' completion of segment 1 of that course, a self-contained portion analogous to a semester. Three research questions guided the study:

1. Among all students who enrolled in segment 1 of the biology course, to what extent did students' rates of completion of segment 1 vary across teachers?

2. Among students who completed segment 1 of the biology course and for whom end-of-segment exam scores are available, to what extent did their score on those exams vary across teachers?

3. Among students who completed segment 1 of the biology course, to what extent did the amount of time to complete the segment vary across teachers?

The study methods are summarized in box 2 and discussed in detail in appendixes A and B.

1. The algorithm prioritizes maintaining equitable teaching workloads by assigning newly enrolled students to teachers who have fewer students. Students' time on the wait list is also a factor.

Box 2. Data sources, sample, and methods

Data sources. The study used student-level administrative data obtained through a data-sharing agreement between the Regional Educational Laboratory Southeast and Florida Virtual School. The data included records of students' course enrollment and completion, end-of-segment exam scores, time to segment completion, and demographic characteristics, including gender, race/ethnicity, grade level, eligibility for the national school lunch program, gifted program status, and honors class status.

Sample. The study sample included four years of data (2014/15–2017/18) to reduce random error in the teacher-level estimates and to balance out any exceptionally positive or exceptionally negative scores for a teacher that might be observed in a single year by random error. The analytical sample for research question 1 on variation in students' segment completion rates across teachers consisted of the 10,618 students in grades 9 and 10 who enrolled in segment 1 of the biology course for the first time in 2014/15–2017/18, regardless of whether they completed the segment, and who did not change teachers, along with their 57 teachers. Thus, research question 1 compared students who completed the segment with those who did not.

The analytical sample for research question 2 on variation in end-of-segment exam score consisted of the 7,712 students who completed the segment and had nonmissing end-of-segment exam scores, along with their 55 teachers.[1]

The analytical sample for research question 3 on time to segment completion consisted of the 7,665 students who completed the segment in more than 3 weeks and less than 47 weeks, along with their 55 teachers. (See figure A1 in appendix A for a description of the analytic samples.) Based on Florida Virtual School guidance, students who completed the segment in less than 3 weeks or more than 47 weeks were excluded from the sample because, according to school staff, these cases could have been a result of data entry errors or other unusual circumstances. However, excluding these students did not affect the results of the analyses. To ensure reliable estimates of teachers' influence on student outcomes, each analytical sample included only teachers who had at least 15 students in that sample combined across four years.

Methods. Teacher influence is conceptualized as the relationship, or association, between a given teacher and the outcomes for the teacher's students. This study used a two-level hierarchical linear model to examine teacher influence on student outcomes. A two-level model recognizes that students are nested, or organized, by teacher. As a result, the outcomes of students who share a teacher and thus who share the same instructional environment tend to be more similar to each other than to the outcomes of students with different teachers. The more influence a teacher has on students, the more the outcomes for those students become like each other. This leads to greater variation among students who are taught by different teachers (greater between-teacher variance) than among students who share a teacher (within-teacher variability). (See box 1 for more information on between- and within-teacher variability.)

These models estimated variation associated with teachers after adjusting for the fact that some variation would be observed due solely to chance. The model allowed the study team to compare the extent of variation between teachers for students' segment completion rates, end-of-segment exam scores, and time to segment completion. High between-teacher variance would indicate that some teachers in the sample had students with systematically higher completion rates, end-of-segment exam scores, and time to segment completion than other teachers in the sample. To determine the amount of variation between teachers, the study team calculated the intraclass correlation coefficient for each model (the ratio of the teacher variance to the total variance).

The report presents three measures of teacher influence. The first, based on the intraclass correlation coefficient, is the percentage of variation in a given outcome that was found at the teacher level. A higher percentage implies greater influence by teachers over that outcome. The second measure compares the outcomes for two hypothetical students. By ranking teachers by the estimated average outcomes of their students, this measure provides a sense of the overall impact of having a higher-ranked teacher rather than a lower-ranked teacher. This analysis compared the expected outcome for a hypothetical student of a teacher ranked at the 75th percentile on the three student outcomes and the outcomes for a similar student of a teacher ranked at the 25th percentile. The difference in expected outcomes for these students, to the extent that it is driven by teacher influence, shows the improvement expected for the student of the higher-ranked teacher. The third measure is standard deviation units, calculated as the square root of the intraclass correlation coefficient. This measure is commonly used in studies of education interventions and can be used to compare the results to those found in other studies. See appendix A for more details.

Limitations. This study was designed to measure patterns of variation among students and teachers, not cause and effect. The study had several limitations. First, it is not possible to measure all factors potentially associated with better student outcomes.

For example, the study did not account for student motivation. Measures of teacher performance, such as the ones used in this study, can be influenced by unobserved factors if they are not randomly distributed across students (Schochet & Chiang, 2010). Studying large groups of students over multiple years can mitigate this limitation but not completely eliminate it.

Second, the results might not be applicable to other online contexts. Two characteristics of the Florida Virtual School online environment might have influenced the observed results. First, students who score below 75 percent on a pretest have to retake it until they achieve at least 75 percent before they can take the end-of-segment exam. Second, the end-of-segment exam includes both teacher- and computer-graded portions. To the extent that the teacher-graded portion was more subjective, this could alter the association between individual teachers and student scores.

Third, other factors might also affect the level of teacher influence found in this study. For example, in traditional in-person courses, teachers and students interact in real time, with instant two-way communication. Florida Virtual School's hiring and training processes might also reduce the variation in observed teacher influence because all teachers operate within the same processes and with the same tools. For example, all teachers receive a list of students to contact each week, and teachers contact all students and parents at least monthly.

Fourth, it is possible that these results would not extend to other levels of education or to subjects other than biology. For example, the association between teachers and students might differ in high school and lower grades (Lipsey et al., 2012). In addition, teachers could have different opportunities to influence student outcomes in other subjects if, for example, students need different amounts of help from teachers in comprehending the course material in other subjects.

Note

1. In the data provided to the study team, there were no missing data in the course completion outcome and time to completion outcome. Among the students who completed the segment 1 of the biology course, the end-of-segment scores were missing for 49 students (0.6 percent of the students who completed the segment). No data were imputed for these missing values.

Findings

Teacher influence was estimated both with and without adjusting for student demographic characteristics because such characteriscs can influence the results (see appendix B for more detail). The study team also examined predicted outcomes for students depending on their teacher's higher or lower ranking in terms of the relationship between teacher and student outcomes.

Overall, the strongest association between Florida Virtual School teachers and student outcomes was for time to segment completion and the weakest association was for end-of-segment exams, with completion rates falling in between

Most teachers had little overall influence, meaning that the relationship between teacher and student outcomes is roughly equivalent across most teachers. But the difference in outcomes between a student who had a higher-ranked teacher and a similar student who had a lower-ranked teacher was noteworthy for some outcomes. Students of a teacher ranked at the 75th percentile had consistently better outcomes than students of a teacher ranked at the 25th percentile (table 1).

For segment completion rates 3.1 percent of the variation was between teachers, but that share dropped to 1.4 percent when the influence of student demographic characteristics was taken into account

While 73 percent of students completed the segment, the difference in completion rates between a hypothetical student of a teacher ranked at the 75th percentile for this student outcome compared with a similar student of a teacher ranked at the 25th percentile was expected to be 9 percentage points (see table 1). The expected completion rate was 78 percent for a student of a higher-ranked teacher and 69 percent for a student of a lower-ranked teacher. The effect size for teacher differences (difference between two students assigned to teachers

Table 1. Teacher influence on student outcomes was limited, with and without adjustment for student demographic characteristics, 2014/15–2017/18

Outcome	Percent of outcome variation due to teacher	Difference in outcome for a student of a teacher ranked at the 75th percentile and a teacher ranked at the 25th percentile[a]	Effect size[b]
Segment completion rates			
No statistical controls	3.1	9.1 percentage point increase in completion rate	0.18
Adjusted for student demographic characteristicsc	1.4	5.0 percentage point increase in completion rate	0.12
End-of-segment exam scores			
No statistical controls	0.7	Increase of 0.75 percentage point in correct answers	0.08
Adjusted for student demographic characteristicsc	0.0	Increase of 0.60 percentage point in correct answers	0.02
Time to segment completion			
No statistical controls	4.9	Segment completed 2.4 weeks faster	0.22
Adjusted for student demographic characteristicsc	4.2	Segment completed 2.4 weeks faster	0.20

Note: The analytical sample for the models with no statistical controls consisted of 10,618 students and 57 teachers for segment completion rates, 7,712 students and 55 teachers for end-of-segment exam scores, and 7,665 students and 55 teachers for time to segment completion. The analytical sample for the model with adjustment for student demographic characteristics consisted of 9,698 students and 57 teachers for segment completion rates, 2,471 students and 54 teachers for end-of-segment exam score, and 7,665 students and 55 teachers for time to segment completion. A large amount of data was missing in the end-of-segment exam score model because of unavailable data on gifted student status. The study team tested the same model excluding the gifted student covariate to calculate the conditional intraclass correlation coefficient using data for 6,934 students and 55 teachers. The conditional intraclass correlation coefficient from that model was 0.006.

a. The differences in outcome for a hypothetical student of a teacher ranked at the 75th percentile and a similar student of a teacher ranked at the 25th percentile using the actual rankings of the teachers based on the estimated teacher effects.

b. The effect size is d-type (see appendix A).

c. Student demographic characteristics included eligibility for the national school lunch program, gifted student status, honors class status, race/ethnicity, gender, and whether the student is new to taking courses with Florida Virtual School. For each outcome the final model retained different demographic variables, based on those that were statistically relevant. See table B5 in appendix B for more detail on these models.

Source: Authors' analysis of data from Florida Virtual School.

one standard deviation apart in the distribution of average outcomes) was 0.18 before the adjusting for student demographic characteristics and 0.12 after making the adjustment.

For end-of-segment exam scores 0.7 percent of the variation was between teachers, but that share dropped to 0 when the influence of student demographic characteristics was taken into account

The average score for all students was 77.9 percent. A student of a teacher ranked at the 75th percentile for this student outcome could be expected to score 0.8 percentage point higher on the end-of-segment exam than a similar student of a teacher ranked at the 25th percentile (see table 1). The expected score was 78.3 percent for a student of a higher-ranked teacher and 77.5 percent for a student of a lower-ranked teacher. The effect size for teacher differences was 0.22 before adjusting for student demographic characteristics and 0.20 after making the adjustment.

For time to segment completion 4.9 percent of the variation was between teachers, but that share dropped to 4.2 percent when the influence of student demographic characteristics was taken into account

The average number of weeks to complete the segment was 19.8. A student of a teacher ranked at the 75th percentile could be expected to complete the segment 2.4 weeks faster than a similar student of a teacher ranked at the 25th percentile (see table 1). The expected time to complete the segment was 18.9 weeks for a student

of a higher-ranked teacher and 21.3 weeks for a similar student of a lower-ranked teacher. The effect size for teacher differences was 0.18 before adjusting for student demographic characteristics and 0.12 after making the adjustment.

Implications

The motivation for the study was to identify high-performing teachers for further investigation of their instructional practices as an initial step toward identifying high-quality instructional practices and helping other teachers adopt them. The findings suggest that Florida Virtual School might benefit from following up with higher- and lower-ranked teachers to examine whether their teaching practices account for some of the observed differences in student outcomes, particularly for segment completion rates and time to segment completion. A few teachers appear to be able to support their students in completing the segment more quickly than other teachers, and their practices may be replicable by other teachers.

The strength of the relationship between teachers and student outcomes varied by outcome, but understanding the practical significance of this finding requires more research. Future research could include interviews with teachers and students. Interviews with teachers might reveal whether or how they differ in providing students with supplemental supports and content, communicating with students one-on-one, and working synchronously with students in groups. Interviews with students who completed the segment at a faster or a slower pace might also reveal information about teacher practices that could be used to generate hypotheses for further study of how teachers influence student success in online learning.

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REL 2021–056

January 2021

This report was prepared for the Institute of Education Sciences (IES) under Contract ED-IES-17-C-0011 by the Regional Educational Laboratory Southeast administered by Florida State University. The content of the publication does not necessarily reflect the views or policies of IES or the U.S. Department of Education, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.

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Hughes, J., Kisa, Z., & Sharp, D. (2021). *Exploring teachers' influence on student success in an online biology course* (REL 2021–056). U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southeast. https://ies.ed.gov/use-work/resource-library/reports/.

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