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Knowledge decay between semesters☆

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ABSTRACT

Summer learning loss has been widely studied in K-12 schooling, where the literature finds a range of results. This study provides the first evidence of summer learning loss in higher education. We analyze college students taking sequential courses with some students beginning the sequence in the fall semester and others in the spring. Those beginning in the fall experience a shorter break between the courses. We test whether the length of that gap explains the students' performance in the subsequent course. Initial results suggest that a longer gap is associated with lower grades. However, including student fixed effects eliminates the observed knowledge decay with a few exceptions: knowledge decay remains for students in language courses, for students with below-median SAT Math scores, and for students with majors outside STEM fields.

1. Introduction

The knowledge that students accumulate in a semester should prepare them for better performance in future coursework, particularly in closely related courses. However, students typically retain only a portion of the material they learn. Estimates of how much they retain are mixed. Deslauriers and Wieman (2011) claim that a majority of factual information is lost within the first year if there is not further relearning or reviewing, and most of that forgetting occurs within the first three months. Elementary and secondary school students may also suffer learning loss during the summer. The claim is that, while home from school, students forget academic material more quickly than when in school; this may be particularly true for lower income students (Alexander, Entwisle, & Olson, 2001) with less-enriching summer environments such as camps and lessons. Out of concern for summer learning loss, some K-12 schools have recently begun taking shorter breaks between terms, with mixed results (Cooper, Nye, Charlton, Lindsay, & Greathouse, 1996; Cooper, Valentine, Charlton, & Melson, 2003).

To date, the analysis of summer learning loss has been limited to K-12. We consider this possibility of knowledge decay in a previously unexamined group: college students. We analyze student performance in the second course of a collegiate two-course sequence as a function of the time lapse between the two courses. When courses are sequenced, such as Spanish 101 and Spanish 102, students typically take the sequence in subsequent semesters. However, the semester in which a given student starts a sequence, fall or spring, determines

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the amount of time between these courses. Taking the first course in a two-course sequence in the fall means the follow-up course occurs in the spring semester, after a month-long winter break. When a student takes the first course in the spring semester but still enrolls in the second course one semester later during the fall semester, there is a longer, three-month break between the courses. We examine whether this longer break between courses affects the student's grade in the subsequent course.

We take advantage of a unique data set that allows us to look at detailed student-level variation. Utilizing 20 years of institutional data from Clemson University, we analyze records of students' entire academic careers. Since the typical college student completes multiple two-course sequences throughout a college career, we observe the same student's outcomes in multiple sequences with differences in the time between the courses. This within-student variation allows us to include student fixed effects and control for unobservable student traits that could be correlated with course scheduling choices.

OLS estimates suggest that longer gaps between the sequenced courses leads to knowledge decay that is measureable and statistically significant. However, this effect disappears with the inclusion of student-level fixed effects. Only one previous study (McMullen & Rouse, 2012) has been able to estimate knowledge decay both with and without student-level fixed effects. Like them, we find that knowledge decay found in the baseline estimates are driven by student-level differences, not the time lapsed between the courses. We do find some situations where knowledge decay still exists with the inclusion of student-level fixed effects: in language courses, for students who score below the sample median in SAT Math, and for students with majors outside of the STEM fields.

2. Background

The debate over knowledge decay has been concentrated in the K-12 literature. Studies focus on the overall impact of summer vacations—the long annual break—on student learning. The decay in knowledge that happens over the break has been called the summer learning loss (Cooper et al., 2003; Kneese, 2000). Some studies have estimated that this loss is large: "the summer loss equaled about one month on a grade-level equivalent scale, or one tenth of a standard deviation relative to spring test scores" (Cooper et al., 1996). Several studies document declines in student test scores over the summer that are larger for disadvantaged and minority students (Alexander, Entwisle, & Olson, 2007; Burkam, Ready, Lee, & LoGerfo, 2003; Downey, Hippel, & Broh, 2004; O'Brien, 1999).

The policy-relevant question in K-12 is whether an alternate school calendar would improve student outcomes. Both traditional school years and year-round schooling include the same number of educational days; the traditional school year, however, has a long summer break while year-round schooling schedules several short break periods throughout the year. The calendars differ in their length of breaks as well as in their length of continuous school days. Graves (2010, 2011) makes the point that if there is a difference between a year-round and a traditional school year it must be due to non-linearities in learning, in learning loss, or both. If the non-linearity is in the loss, then year-round schooling is better; if the non-linearity is instead in learning, then longer periods of continuous learning are better, and year-round schooling is worse.

Recent evidence using natural experiments suggests that year-round schooling is no better or may even be worse than a traditional calendar. Graves (2010) estimates that test scores fall when students are on a multi-track year-round calendar, a finding supported by the broader literature summarized in Graves, McMullen, and Rouse (2013). Graves (2011) compares year-round schooling to a traditional school calendar using school-specific trends and finds that the largest drop in performance from year-round calendars is in Hispanics/Latinos and low SES students, the same students who other studies found to be likely to suffer summer learning loss. She remains unable to control for student-level unobservables as she does not observe the same student operating under both environments. However, McMullen and Rouse (2012) observe exactly that: they use a natural experiment in North Carolina with student fixed effects and find zero impact from year-round schools. Schools adopted year-round schooling in a mandatory and staggered manner reducing policy endogeneity concerns. Some of the within-student policy variation also stems from students switching schools, typically as they advance to middle school, to a school using a different schedule. In this case self-selection of students into different middle schools may be problematic. In either case, their identifying variation is always perfectly correlated with a student changing a school or with a school changing its policy, both of which could themselves be relevant predictors of student outcomes.

Anderson and Walker (2015) revisit the same question on a smaller scale. Instead of thinking about summer-learning loss, they examine learning loss over the weekend. In particular, they look at whether having a four-day school week, as opposed to the traditional five-day week, impacts learning. Their study finds positive effects of the shorter week and longer break, suggesting that learning loss does not increase over an extra weekend day, and that positive learning non-linearities might exist within a school day.

Although the education research on summer breaks has focused on K-12 students, our study examines this question utilizing data from a sample of students in higher education. We estimate the impact of break lengths between courses in a sequence. We compare student performance over sequenced courses taken before and after the shorter winter or the longer summer break.

Our paper adds to the literature in two ways: first, it better measures how time affects knowledge decay because it allows for student fixed effects in an environment where the school and the school's scheduling policy remain constant throughout the sample. Only one