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The relative benefits of live versus online delivery: Evidence from virtual algebra I in North Carolina

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ABSTRACT

Over one million K-12 students pursue virtual education every year, but researchers know very little about the effectiveness of such programs. This paper exploits a district policy change that suddenly shifted advanced eighth graders into a virtual classroom for Algebra I. After the policy, higher-ability eighth graders in the treatment district began taking Algebra I in the virtual classroom at rates similar to the statewide average of their peers in traditional classrooms.

The change in course delivery provides a unique opportunity to study effects of a virtual course on academic outcomes. The analysis uses variation in program uptake across performance quintile, district, and year in a difference-in-difference-in-difference approach to estimate the causal effect of the virtual course, finding that eighth grade virtual students tend to underperform relative to eighth graders who took Algebra I in a traditional classroom *and* relative to pre-policy, same-district students who had to take the course in ninth grade.

1. Introduction

Virtual K-12 courses have the potential to increase equity in access to courses at a lower cost than traditional classrooms. High-ability, motivated rural or urban students may not have the same opportunities to take advanced courses as they would if they had the same resources as students in suburban schools (Picciano & Seaman, 2009; Sipple & Brent, 2007). Virtual classes may offer policymakers a less-expensive way to level the playing field (Berge & Clark, 2005; Peterson, 2011). At the same time, suburban or other schools may also look to virtual options as a way to reduce costs while maintaining the same course offerings (Berge & Clark, 2005; Peterson, 2011). Not all students will succeed in the virtual environment, and those with higher grades, self-discipline, and technological support at home and school are more likely to succeed (Bakia et al., 2013; Roblyer & Davis, 2008; Waschul, 2005).

Equity and cost considerations have contributed to a rapid expansion in virtual education options for K-12 students, boosted by improved technology in recent years. Over one million K-12 students pursue at least one virtual course every year, and several states now require their students to take at least one virtual course (Watson et al., 2014). However, researchers have conducted few statistically robust evaluations of virtual courses (Barbour, 2014; Means et al., 2010).[1] Given the lack of research on the

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[1] A Department of Education meta-analysis of virtual education found only five K-12 studies that met criteria for content, controls, and data reporting (Means et al., 2010). O'Dwyer, Carey, and Kleiman (2007) found no difference between online and traditional Algebra I using school-level matching in Louisiana. The other four programs used a blended method of instruction, with a traditional classroom supplemented by a virtual component. Among college students, a randomized trial in a full-term economics course found null or negative results, with particularly poor outcomes for Hispanic, male, and low-achieving students

topic, the present paper fills an important gap in the literature by providing causal evidence of the effect of providing an entirely virtual Algebra I course relative to the same course taken in a traditional classroom. The analysis specifically focuses on advanced students taking the course "early" in middle school, rather than ninth grade. High-achieving students may be more prepared for the rigors of taking a virtual course than their less-advanced peers, which provides a best-case scenario for the virtual education evaluation.

Moreover, virtual education offers an important new tool to those who advocate pushing Algebra I to younger grades, particularly for small, rural, or less affluent schools that struggle to attract and retain highly-qualified teachers or to support as many courses as large suburban schools (Bakia et al., 2013; Heppen et al., 2011; Picciano & Seaman, 2009). Early Algebra I advocates generally offer two arguments: that Algebra I functions as a "gateway" course to advanced classes in high school and beyond, and that success in middle school algebra leads to success in later math courses (e.g., Nord et al., 2011; Smith, 1996; Spielhagen, 2006). Heppen et al. (2011), one of the few robust studies of virtual education, use random assignment to examine the effectiveness of using a virtual course to broaden access to Algebra I for eighth grade students, relative to the "business as usual" eighth grade math classes, many of which included some algebra content. Providing a virtual Algebra I course to eighth-grade students improved their algebra knowledge at the end of eighth grade, relative to control students. Treatment students were also more likely to pursue an advanced course sequence in ninth and tenth grade, though these advantages were somewhat offset by control students "doubling up" on math courses in ninth and tenth grade (Heppen et al., 2011).

Recent research demonstrates that there is a "leak in the pipeline" from Algebra I to higher math courses (Liang et al., 2012, p. 338), and that expanding access to eighth grade Algebra I for lower-performing students may actually lead to worse outcomes for those students (Clotfelter et al., 2015; Hansen, 2013; Loveless, 2008). In North Carolina, students in traditional classrooms have lower scores when they are first exposed to Algebra I in eighth grade rather than in ninth grade, though they tend to pass Algebra I by tenth grade at higher rates (Clotfelter et al., 2015; Hansen, 2013). In higher-level math courses, it is mainly higher-achieving students who benefit from earlier access to Algebra I.[2] In terms of increasing equity in course availability via virtual courses, the benefits of expanded access to virtual Algebra I may then mainly be accrued by advanced students and may actually harm average students.

When deciding whether to pursue virtual education options, policymakers must balance a complex set of cost, equity, and academic considerations. The present paper asks two policy-relevant questions. First, it examines how eighth graders in virtual Algebra I perform relative to ninth graders in traditional Algebra I. This analysis provides a reference point for policymakers hoping to use Algebra I to expand equity in course availability using virtual schools. Importantly, equity in access does not guarantee equity in learning, and policymakers must weigh the potential benefits of earlier access against possible lower performance in the virtual platform. Second, it examines how eighth graders in virtual Algebra I perform relative to eighth graders in traditional Algebra I. This analysis provides a point of reference for policymakers hoping to save money by switching from a traditional to a virtual course. Such a switch may lead to monetary savings, but with the cost of lower academic performance.

To explore these questions, the analysis exploits a district policy change that suddenly shifted advanced eighth graders onto the North Carolina Virtual Public School (NCVPS) platform for Algebra I. In 2011, Columbus County Schools (CCS) began to exclusively use NCVPS Algebra I in its middle schools. Throughout North Carolina, higher-ability students (as measured by prior test scores) are more likely to take Algebra I in middle school than lower-ability students. Before 2011 no CCS middle school students took Algebra I. After the policy change, higher-ability CCS eighth grade students began taking Algebra I via NCVPS, while lower-ability students continued to wait until ninth grade to take the course in a traditional classroom. The treatment timing is arguably exogenous with respect to individual student choice – a post-policy CCS eighth grader was no more likely to excel in Algebra I than a pre-policy CCS eighth grader. By the chance of his year of birth, the post-policy student was simply given the option to do so. The change in the delivery of Algebra I provides a unique opportunity to study the causal effects of a large, state-run virtual course on advanced students' academic outcomes. The comparison within CCS includes both the option to change from traditional to virtual education *and* from ninth grade to eighth grade.

The paper also compares the outcomes of eighth graders in virtual and traditional courses. The ability distribution of eighth graders who opt into Algebra I in CCS matches that of North Carolina as a whole, indicating that CCS did not under- or over-subscribe students to the course. The treatment available is then arguably exogenous with respect to individual student choice – a post-policy CCS eighth grader likely did not desire a chance to pursue Algebra I more than a non-CCS eighth grader in that same year. However, the method of course delivery differs by county. The analysis thus includes other North Carolina

(Figlio, Rush, & Yin, 2013). Other studies find that undergraduates perform about the same in virtual and traditional courses, with blended programs having a positive effect (Bowen, Chingos, Lack, & Nygren, 2014; Zacharia, Olympiou, & Papaevripidou, 2008; Zhang, Zhou, Briggs, & Nunamaker Jr., 2006). It remains unclear to what extent these results apply to K-12 students.

[2] Clotfelter et al. (2013) find that students in districts where students are placed into taking Algebra I in eighth grade achieve lower scores in Algebra I and are less likely to pass later math classes, particularly geometry, relative to students who wait to take Algebra I in ninth grade. These negative effects are almost entirely attributed to students in the bottom three quintiles of the prior achievement distribution. Similarly, lower-performing students are no more likely to take calculus; instead the expansion of Algebra I to earlier grades only helps students in the top 20% of the prior test score distribution. Note that with Common Core, North Carolina now offers Math I, Math II, and Math III rather than discreet Algebra I, Algebra II, and Geometry courses for high school students, but qualified eighth grade students are still able to take these courses early in middle school.