Virtual Success: Examining the Effectiveness of the North Carolina Virtual Public School

A Master's Project submitted in partial fulfillment of the requirements for the degree of Master of Public Policy in the Sanford School at Duke University

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EXECUTIVE SUMMARY

Although virtual education options have rapidly expanded in recent years, little academic research has examined the effectiveness of these courses. My analysis examines the North Carolina Virtual Public School (NCVPS) and specifically uses the state Algebra I and English I end-of-course (EOC) tests to compare the academic outcomes of students in a statewide, entirely virtual classroom to those in a traditional brick-and-mortar setting. I also use a survey of NCVPS students to examine how students experience the virtual system and why they selected that option.

I find that students use NCVPS for two distinct reasons. On one hand, certain students use the course as an *opportunity* to take an overload of courses or to pursue a course not offered in their local school. These students typically live in rural areas, but they are typically not poor and have a history of academic success. A majority of Algebra I NCVPS students fall into this category, because many rural middle schools use NCVPS to offer a high school course they would otherwise be unable to provide. Such students are likely to do well no matter which system they use. On the other hand, certain students use NCVPS as an *accommodation*, often to keep them on track for graduation. These students often live in urban area and are typically economically disadvantaged with a history of low academic performance. Such students are likely to struggle either virtually or in a traditional classroom. Not surprisingly, my survey results indicate that these students are often very worried about the lack of guidance and support in NCVPS.

A complicated picture emerges as I examine NCVPS student survey responses. What certain students see as a benefit, others see as a drawback. Some students love the freedom of the virtual environment while others want more structure. The particular opinions depend on students' past experience, familiarity with the system, and comfort level with self-directed work. Policymakers need to balance student preferences with the benefits of the virtual classroom.

Determining the effectiveness of NCVPS is not as easy as comparing the average results of students using each system. For example, students using NCVPS for Algebra I in ninth grade have substantially lower scores on the Algebra I EOC test than their traditional peers. However, these NCVPS students' math scores had been on a downward trajectory in the years *before* they began their virtual Algebra I course, while traditional students' scores were fairly stable over time.

Such differences are interesting as a descriptive exercise in that they illuminate that certain NCVPS students would need more academic support in either the virtual or traditional system. One cannot draw causal conclusions from such differences, however. They probably have more to do with the characteristics of students who choose the virtual option than with the effectiveness of NCVPS. It's not clear that NCVPS caused the difference in scores. To draw any conclusions, I need a counterfactual: a comparison of what *did happen* (say, in NCVPS) to what *would have happened* if the student had been placed in a traditional classroom. Thus, I focus my main analysis on middle

schools, several of which only offer NCVPS Algebra I and several of which only offer traditional Algebra I.[1] Removing an element of choice allows a more causal conclusion.

I find that eighth grade students perform about as well in Algebra I NCVPS as they do in the traditional classroom. Sixth and seventh grade students, however, struggle in the virtual system relative to comparable peers. These results are consistent across a variety of models, including simple OLS regression, propensity score matching, and a panel approach. My research supports several implications for NCVPS managers, school and district administrators, and state policymakers.

1. *Rural middle schools without the capacity to offer a traditional Algebra I course should allow advanced eighth grade students to take the course through NCVPS.*

   My research consistently demonstrates that virtual eighth grades students perform about the same on the EOC test as similar traditional students. Although more research is needed, this finding may also extend to advanced students in other subject areas. On a related note, schools should also allow advanced students to use the virtual option to take an overload of courses if they are deemed capable of handling the additional work.

2. *NCVPS does not work for all students, and certain students need special support.*

   My research consistently finds that young students using NCVPS as an opportunity in sixth or seventh grade fare poorly in Algebra I NCVPS relative to similar traditional students. Some students may not be ready academically or developmentally to use a self-directed virtual program. In these cases, young students may benefit from waiting until eighth grade before pursuing NCVPS.

   Additionally, many students that pursue NCVPS as an accommodation have a history of academic struggles, meaning they likely need an entirely different support system than advanced, high-achieving eighth graders. NCVPS should consider this balance as they assign students to classrooms, and more research should focus on what particular methods and means of support work best for at-risk students in the virtual environment.

3. *School and state policymakers need to stay up-to-date with technology needs and advances.*

   Schools should employ better screening to ensure that students have access to the technology they need to succeed in NCVPS. Over 10% of NCVPS students reported having no computer at home. This limitation likely affects less affluent students disproportionately, and these students are not set up for success if they cannot access course content at home.

[1] Not enough middle school students pursue English I, so I exclude this subject from the analysis.

> Additionally, student survey responses indicate that many students prefer the support, guidance and physical presence of a traditional classroom. NCVPS could do more to support students' learning needs. As technology moves forward, NCVPS should learn from best practices of other systems. For instance, perhaps NCVPS could supplement its PowerPoint slides with standardized video lectures that can be used by all teachers year-after-year. A video of a teacher manually working through a problem or topic may be more beneficial than a series of slides.

Overall, North Carolina has developed one of the leading virtual systems in the country. It seems unlikely that virtual education will go away any time soon, and the rapidly expanding interest in virtual options mean that other states will look to other programs as models. North Carolina's program works well for advanced eighth grade Algebra I students, although it does not work for all students. By focusing on targeted growth and meeting student needs, NCVPS can offer North Carolina students an exceptional program that other states could model.

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I. INTRODUCTION

Virtual education options for high school courses have rapidly expanded in recent years. The Sloan Consortium, a nonprofit organization committed to expanding online education, estimated that over one million K-12 students engaged in online courses in 2007-08, a 47% increase over 2005-06 (Picciano and Seaman, 2009). The International Association for K-12 Online Learning estimated that 1.5 million students pursued online learning in 2009-10 (Wicks, 2010). Private education management organizations, charter schools, and single-district programs provide many of these students with online education. Thirty-nine states sponsor statewide virtual public schools, but Florida and North Carolina account for 98% of nationwide enrollment. Statewide programs had 450,000 course enrollments in 2009-10, an increase of 40% over the prior year (Watson et al., 2010).[2] In certain states, virtual education is no longer an optional supplement. The state of Virginia now requires all students to take at least one virtual course to graduate (Brown, 2012).

Virtual courses provide students an opportunity to pursue topics that would be otherwise unavailable, often at a lower cost than in a traditional classroom. Virtual courses also allow schools to accommodate student needs, with online options providing flexibility for students with health problems, scheduling conflicts, and/or missing graduation requirements. In other words, virtual courses represent an *opportunity* for some students and an *accommodation* for others.

Despite rapid expansion, researchers have conducted few statistically robust research evaluations of K-12 student outcomes in virtual courses. Most expectations about virtual education effectiveness for K-12 students depend on assessments performed at the undergraduate level or on outdated modes of distance education. Research confirms that education improves a variety of life outcomes (see Oreopoulos and Salvanes, 2011), but particularities in course content, pedagogical techniques, and classroom interactions may differentially affect the returns to education for certain students. Considering the rapid expansion of virtual high school options, further research is needed to understand the true effectiveness of these courses for particular student groups.

This paper examines the efficacy of the North Carolina Virtual Public School (NCVPS) Algebra I and English I online courses. The analysis exploits a required statewide end-of-course (EOC) test in each of the courses to contrast outcomes between students in NCVPS and traditional brick-and-mortar classrooms. For a variety of reasons, I limit the causal modeling to an examination of the EOC test score differences between middle school students who can only pursue Algebra I through NCVPS versus middle school students who only have the traditional option available. The modeling specifically focuses on how NCVPS affects student achievement on the Algebra I EOC.

The remainder of this paper proceeds as follows: Section II reviews the recent literature, and Section III provides an overview of the North Carolina virtual system and other state-specific context. Section IV examines the data used in this analysis. Section V outlines a descriptive analysis of student characteristics and selection into virtual education, including an overview of a survey of NCVPS students. Section VI outlines my analytical strategy for examining the achievement effects

[2] One enrollment equals one student taking one semester- or year-long course.

of virtual schools, and Section VII concludes the paper with a discussion of the limitations of the study and preliminary implications of the findings.

Before continuing, a few definitions are in order. "Virtual education" specifically refers to recent internet-based programs, while "distance education" includes virtual education programs and other methods such as videoconferencing or mail correspondence courses. "Blended" programs refer to education curricula that combine distance learning with a traditional classroom setting. Unless otherwise noted, a "virtual course" refers to a course taught online, without classroom supplementation. A "virtual school" refers to a system, either public or private, that offers only virtual courses. Students may take some or all of their courses through virtual schools.

II. LITERATURE REVIEW

Virtual courses can expand course offerings (Berge and Clark, 2005; Cavanaugh, 2001; Christensen, 2008; Sipple and Brent, 2008), provide choice (Berge and Clark, 2005), keep students on track for graduation with remedial courses (Christensen, 2008), and lower per student costs (Peterson, 2010). In particular, economies of scale can substantially lower costs for large virtual high schools (Berge and Clark, 2005; Christensen, 2008).

High-need rural and urban schools may particularly benefit from virtual options. Such schools struggle to attract and retain highly qualified teachers for a variety of reasons (Ingersoll, 2001; Sipple and Brent, 2008). Clotfelter, Ladd, and Vigdor (2010) found that teachers in high-poverty North Carolina high schools have much lower qualifications than teachers in more affluent schools, and these differences systematically affect student achievement. Additionally, small schools may not have enough interested students to support as many courses as larger schools. Virtual education allows small, less affluent schools to offer courses that they would be otherwise unable to provide. Further, virtual offerings can provide access to highly qualified teachers for more students.

Prior studies have concluded that students in virtual education perform about as well as students in traditional classrooms. These studies used some measure of academic performance as a gauge of effectiveness, but many analyses lacked statistical rigor. For instance, Cavanaugh's (2004) often-cited meta-analysis found no significant difference between online K-12 courses and traditional classrooms, but the team did not base results on controlled studies. Instead, they compared school-wide results without controlling for student-level characteristics.[3] Similarly, a Florida Tax Watch (2007) report found that students in the Florida Virtual School earned better grades, Florida Comprehensive Assessment Test results, and AP test scores than traditional students, but again the analysis compared averages without controlling for student characteristics.

Recent news investigations uncovered several problems with virtual schools run by nonprofit and for-profit education management organizations (EMOs) across the country (Larson,

[3] The reference section of the meta-analysis refers the reader to the spring 2003 benchmarks for the Delta/Greely school district on the Alaska Department of Education's website, several Colorado accountability reports, the Indiana Department of Education's school snapshot of the Irvington community school system, etc. Many of the links in the reference section no longer work, and additional searching cannot locate the original data.

2011; Saul, 2011; Anderson, 2012). The investigators argue that virtual EMOs indiscriminately recruit students into the system, collect revenue based on the number of enrollees, and offer limited support to struggling students. In Colorado, half of online students left the program within a year, and many students fell further behind than when they started. Ultimately, traditional schools re-admitted the students, but with a reduced budget because tax dollars had been funneled to the online school (Larson, 2011). Similar problems occurred in other locations across the country (Saul, 2011). In 2010-11, only 27.4% schools operated by for-profit EMOs met No Child Left Behind's Annual Yearly Progress standards, while the number of virtual schools operated by EMOs grew from 17 in 2003-04 to 79 in 2010-11 (Miron et al., 2012). However, most of these analyses did not match virtual students to similar students in a traditional setting, and it remains unclear how the students would have fared had they remained in the regular classroom.

A 2010 U.S. Department of Education meta-analysis of the efficacy of virtual education found only five K-12 studies that met its criteria for content, controls, and data reporting from 1996 to 2008 (Means et al., 2010).[4] The meta-analysis most commonly rejected studies for not using statistical controls in quasi-experiments, while other studies did not analyze learning outcomes or did not have a control group. Appropriate statistical techniques are vital to avoid selection bias. As Peterson (2010) points out, the most resourceful students may be most likely to try innovative practices such as virtual education. Alternatively, perhaps the most at-risk students are more likely to need the accommodations that virtual education can offer.

The five K-12 programs that met the Department of Education requirements ranged widely in subject matter and grade level. See **Appendix A** for additional information about the five studies. Most used a blended method, with the online component supplemented by classroom-based instruction, and they bore limited resemblance to the rapidly expanding virtual schools that provide entirely online instruction to thousands of high school students each year. A recent search found limited additional research that met the Department of Education criteria.[5] One study found that tenth grade students in an all-girls school in Taiwan learned more about electrical wiring through online simulations than through lectures, demonstrations, and group work (Liu and Su, 2011).

Researchers have also conducted studies on undergraduate virtual education and general distance K-12 learning. Among undergraduates, research generally concludes that virtual education students perform about as well as those with face-to-face instruction, with blended programs having a somewhat positive effect (e.g., DeBord, Aruguete, and Muhlig, 2004; Zacharia, 2007; Zhang, 2005;

[4] Qualifying studies had to (1) involve learning that took place over the Internet, (2) contrast conditions that varied in terms of use of online learning, (3) describe an intervention study that had been completed, (4) report a learning outcome that was measured for both treatment and control groups, (5) use a controlled design, and (6) report sufficient data for effect size calculation or estimation. Of the 522 studies the analysts read, only 99 met the stated criteria, only nine involved K-12 students, and only five included sufficient data and controls (Means et al., 2010).

[5] A search of the ERIC database spanned from August 2008 (the first month not included in the meta-analysis search) to March 2012. The search included the terms listed on Table A-1 of the Department of Education report and the phrase "high school." I used "and" between search terms. The search rejected any research on blended programs; for instance, I rejected Liao and She (2009) because (1) the program used in-person teachers to answer student questions and (2) internet-based students participated in in-person laboratory sessions. I rejected Izzo et al. (2010) because it is an add-on program, not a full course. Notably, both studies found successful results for the online classroom.

Zhang et al., 2006). Cavanaugh's (2001) meta-analysis examined nineteen studies that compared a variety of forms of interactive distance learning with traditional classroom instruction for K-12 students.[6] The meta-analysis found a mean effect size of +0.15 standard deviations for all forms of distance education. Excluding the blended programs, the mean effect size dropped to -0.01 standard deviations. Neither result differed statistically from zero. Other analyses involving distance education outside the K-12 range similarly found no significant differences between distance and face-to-face instruction (e.g., Shachar and Neumann, 2010; Bernard et al., 2004).

Policymakers should not assume that success in one area of distance education will translate into success in K-12 virtual education for two main reasons. First, they cannot necessarily generalize results from general K-12 distance education to the virtual environment. The meta-analyses by Bernard et al. (2004) and Means et al. (2010) emphasize the heterogeneity of distance education outcomes. A variety of factors contribute to success. Bernard et al. (2004) specifically warn that the "wide and unexplained variability" of outcomes should preclude over-generalizations in distance education (p. 404). Context and specific implementation strategies are important.

Second, policymakers cannot always generalize results from one group of students to another. In their summary of virtual education, Barbour and Reeves (2009) point out that most theories of distance education are intended for adult learners, but ample research confirms that children's learning substantially differs from that of adults. Adolescent brains continue developing throughout the high school years (Tiemeier, et al., 2010). Ratelle et al. (2007) find that high school students display more controlled motivation (i.e., acting for reward or to avoid punishment), whereas college students exhibit more autonomous motivation (i.e., acting out of choice). High school students may need more guidance and structure than college students, and in turn sixth or seventh grade students may need more guidance than high school students.

Further, it may be easy to convert large, lecture-based college courses into a virtual course. As Christensen et al. (2011) observe, "Everything [is] distance beyond the fifth row" (p. 53). The same may not necessarily apply to small, interactive high school classrooms. Finally, the more motivated, independent, and academically gifted students tend to pursue virtual education first (Barbour and Reeves, 2009). As more students enroll online, it seems probable that those with a lower propensity for success will join the movement.

Education Week recently noted that virtual education remains largely understudied (Davis, 2012). Despite rapid expansion, few rigorous, scientific studies have evaluated virtual courses at the K-12 level. Given the expanding scope and uptake of such programs, further study is needed.

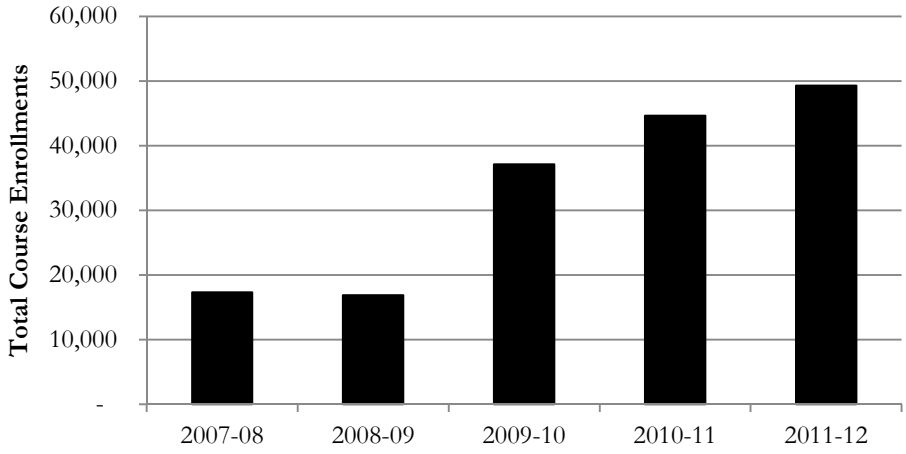
III. North Carolina Context

NCVPS rapidly expanded after its inception in 2005. Figure 1 displays the growth of NCVPS by academic year. The program grew from less than 17,500 in 2007-08 to nearly 50,000 in 2011-12. NCVPS is the second largest public high school in the United States, second only to

[6] Thirteen studies used videoconferencing, five used email, and one used the internet to connect students and teachers.

Florida Virtual Schools. In 2011-12, NCVPS offered 115 different courses, including 47 AP or honors courses, eight world language courses at various levels, 12 credit recovery courses for students who previously failed a course, four blended learning Occupational Course of Study (OCS) courses for special needs students, and a variety of required and elective courses.[7]

FIGURE 1: ESTIMATED TOTAL NCVPS COURSE ENROLLMENTS BY YEAR[8]



As students began to see the benefits of NCVPS, the supply of course slots has not kept up with demand. In late 2011, unexpectedly high enrollment caused fifteen school districts to spend their entire NCVPS budget allocation before spring enrollment (Hui, 2011). Enrollment exceeded projections by nearly 2,000 students in the fall semester. Wake County alone had 1,047 students enrolled in NCVPS in the fall, more than double the projected enrollment. A $3 million shortfall led DPI temporarily to block students in fifteen districts from enrolling in NCVPS, and districts began to determine which students most needed NCVPS. For example, Wake began to prioritize students that needed virtual courses to graduate in the spring. A thorough understanding of what type of students tends to succeed in NCVPS could help with slot allocations during future shortages.

Currently, middle school students can only use NCVPS for high school courses. For instance, they can take Algebra I but not an eighth-grade level math course online. NCVPS must ensure e-learning opportunities for students in rural and low-wealth counties (HB202, 2009). See **Appendix B** for NCVPS operational details and **Appendix C** for an analysis of whether NCVPS provides services to its intended recipients.

An internal DPI assessment found that, controlling for a variety of student-level characteristics, NCVPS students passed their EOC tests with less frequency than traditional students in 2009-10 (Banks, Bodkin, and Heissel, 2011). The review also found that students in NCVPS were more likely to have a history of disciplinary and academic problems. However, issues with linking databases prevented an in-depth review of past data. Recent changes to DPI's IT system allow better linking, thereby providing the more complete dataset used in the present study.

[7] See **Appendix B** for a full list of NCVPS course offerings in 2011-12.
[8] NCVPS provided enrollment data via personal communication in 2011 and 2012.

IV. DATA

DPI provided the data for this study. The dataset includes student-level details for all students who completed an end-of-course (EOC) test in Algebra I and/or English I in the 2010-11 school year. The DPI database links test results to a rich set of student characteristics, including demographic details and past test scores. A separate DPI table provides FRL data at the school level. I also use data from the National Center for Education Statistics (NCES) to identify schools' and districts' metropolitan classification (city, suburb, town, and rural) and racial composition.[9] Census data provides county-level median income estimates (in 2009 dollars).

The study compares NCVPS classroom EOC test results to traditional public school results at the student level. I exclude courses taken through a Juvenile Justice Center, Health and Human Services location, or other state-level institution, as well as non-NCVPS virtual courses such as NovaNet and OdysseyWare. The analysis includes charter schools but not private schools. The study only examines regular course types. I exclude credit recovery and OCS courses due to their unique populations and pedagogical methodologies.[10] In total, the study excludes 2.6% of the total Algebra I test-takers and 1.9% of the total English I test takers.

The population includes 122,419 Algebra I students and 115,206 English I students; 68,760 students appear in both datasets. Table F1 in **Appendix F** provides descriptive statistics for the two populations. North Carolina requires students to take the Algebra I and English I EOC exams, as well as end-of-grade (EOG) reading and math tests every year from third through eighth grade.[11] For Algebra I, the average EOC test score in the dataset is 154.0 with a maximum score of 168.0, and 77.8% of students passed the test. The average English I EOC test score is 152.3 with a maximum of 176.0, and 81.0% of students passed.[12]

I use students' most recent EOG-math test to approximate past performance for Algebra I, and I use the EOG-reading test for English I.[13] For example, I use the 2009-10 seventh grade EOG-math test score for an eighth grade Algebra I student who did not take the EOG-math test in eighth grade. For most students, their most recent result is their eighth grade EOG test score.[14] I standardized the scores by year and grade level to allow a comparison across different testing years, resulting in a "Z-score" with an average of zero and a standard deviation of one for each year and

[9] Note that the NCES code indicates the location of the school that provides access to NCVPS and not necessarily a student's home. However, the associated school is likely local. The NCES data is from 2009-10; for later regression analysis, the racial composition is excluded because the year is lagged and the data is highly collinear with FRL trends.

[10] DPI identified courses taken through NCVPS. I manually identified courses as Credit Recovery or OCS using the course title and code. Because these vary by district, some misidentification may have occurred. I coded as conservatively as possible and defaulted to identifying courses as "Regular" without a clear reason to do otherwise.

[11] If a student fails an EOC or EOG test, he may be allowed to retake the test in the same testing cycle. DPI uses the highest of the scores as the student's result of record, as does this data set.

[12] Algebra I and English I EOC test scores are not comparable; for the remainder of the paper I standardize the scores so that each student has an associated "Z-score" for each test with a mean of zero and a standard deviation of one. Note that the scores are normally distributed in the population.

[13] See **Appendix G** for between-test correlations.

[14] For example, in Algebra I, 68.2% of the most recent EOG-math test score comes from the eighth grade test, 21.6% from seventh grade, 3.5% from sixth grade, and 1.1% from third through fifth grade. Finally, 5.6% had no previous EOG-math test result recorded.

grade level within my entire dataset. Because this is historical data, a little over 5% of students were missing prior test scores. I assume an EOG standardized score of zero (the state average) for these students.[15] For the overall Algebra I population, the mean standardized score was 0.08 for EOG-math and 0.09 for EOG-reading.[16] For English I, the scores were 0.01 and 0.01, respectively.

Table F1 also displays student-level descriptive characteristics. NCVPS students represent 1.5% of the Algebra I and 2.3% of the English I populations. The average grade is about 9 for both courses, using a typical K-12 grade level scale. Some students take the course in middle school, while other students take the course in later years due to academic difficulties. A small majority of students are male, white, and not on free/reduced lunch (FRL) in both groups.[17] Schools have identified 12%-14% of the students as academically/intellectually gifted (AIG) in reading or math. There may be overlap in these groups. Additionally, 10.7% of Algebra I students and 13.6% of English I students are exceptional children (EC), indicating a learning, physical, or emotional disability of some kind. A little over 5% of the students have limited English proficiency (LEP).[18]

Students are distributed across various school types. The location of schools reflects the demographics of North Carolina, with 50% of students in rural schools, about 25% in urban schools, and the others spread across towns and suburbs. On average, students attended schools that were about 47% FRL and 45% nonwhite. Less than 2% of students attended a charter school.

V. Student Characteristics and Sorting Mechanisms

This section describes basic descriptive differences between NCVPS and traditional students, explores potential ways that students may sort into NCVPS, examines their previous test results, and reviews a recent survey of NCVPS students.

A. Characteristics of NCVPS and Traditional Students

Table F2 in **Appendix F** displays a bivariate analysis of the descriptive statistics from Table F1 by classroom type. On average, Algebra I NCVPS students outperformed students in traditional classrooms, both in score (159.1 v. 153.9) and in percent passing (92.3% v. 77.6%). English I NCVPS students underperformed relative to traditional students, both in score (512.5 v. 143.3) and in percent passing (81.9% v. 40.3%). Given this information, one might conclude that the NCVPS Algebra I course is a fantastic success, while English I is not. However, the typical NCVPS student substantially differed from the typical student in a traditional classroom for both courses.

Past test results predict future academic performance. Traditional Algebra I students had an average Z-score of 0.08 on the EOG-math test, compared to 0.79 for NCVPS students. Similar

[15] Removing the missing EOG test scores from the calculation does not change substantially the results.
[16] Note that if I included all students in the dataset, the average would be 0.0, and about 64% of students would fall between +/-1.0 standard deviation. However, due to negative selection among the excluded students, the population average is slightly above 0.0.
[17] Lower-income students can apply for FRL through their schools; they can either receive a reduced price or entirely free lunch. Students are not required to apply for this program, but FRL is a useful proxy for students' family income.
[18] Students that were once LEP can move out of this group once their English improves.

patterns occur in the EOG-reading test for Algebra I students. Thus, it appears that Algebra I NCVPS students have a history of past success on statewide standardized tests. The English I population again shows the opposite pattern: NCVPS students scored lower on the EOG tests than traditional students (-0.89 v. 0.03 for both tests).

In Algebra I, NCVPS students were less likely to be in groups that historically struggle on the EOC exam and more likely to be in groups that excel. There were relatively fewer nonwhite, EC, FRL, and LEP students in NCVPS than in the traditional courses. Algebra I NCVPS also had a larger percentage of AIG students, and the students attended schools with smaller percentages of FRL students. The exact opposite trends occurred in English I.

The students' grade levels provide some insight into how students sort into NCVPS. Students typically take both courses in ninth grade. Students who delay or repeat courses will take them in later grades. Conversely, high-achieving students may elect to take high school courses in middle school. For Algebra I, the average grade level in NCVPS is 7.9; the average in the traditional classroom is 8.9. Figure 2 displays the distribution of Algebra I students by grade.[19] While early-takers (grades 5-8) comprise only 25.4% of traditional students, 91.9% of the Algebra I NCVPS students are early-takers.[20] Conversely, 8.2% of traditional students are late-takers (grades 10-12), compared to only 4.6% of NCVPS students. The proportions indicate that many Algebra I NCVPS students are high-achieving compared to their traditional counterparts; they use NCVPS as an *opportunity* to take advanced courses in early grades.

FIGURE 2: DISTRIBUTION OF ALGEBRA I STUDENTS BY GRADE

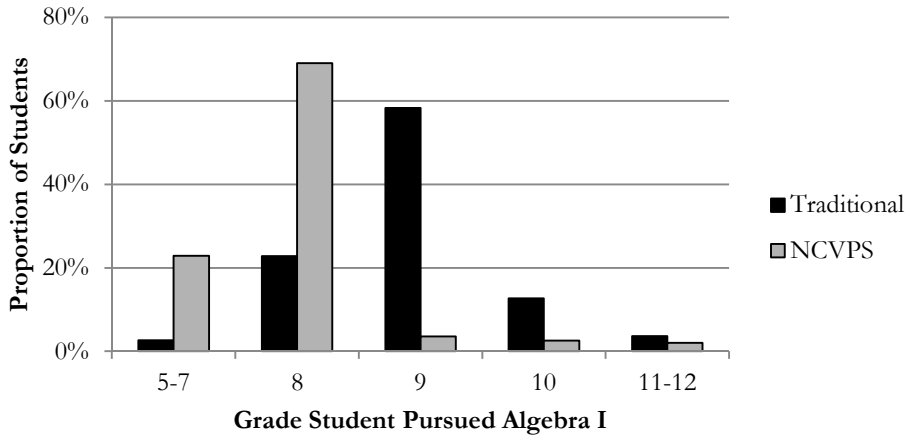


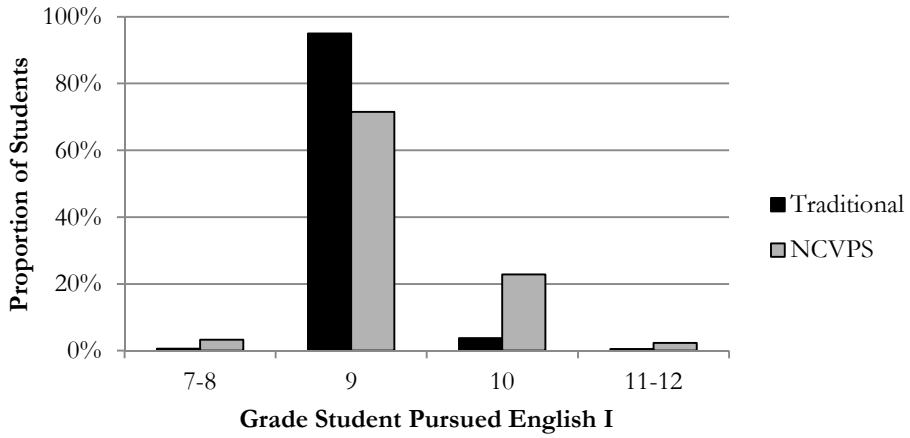
Figure 3 displays the proportion of English I students in NCVPS and traditional classrooms by grade. Early-takers (grades 7-8) comprise a small fraction of English I students in both groups.

[19] The total distribution sums to 100% for traditional students and 100% for NCVPS students in Figure 2.

[20] Notably, though a large proportion of NCVPS students are in the earlier grades, these students represent a small portion of the total students taking the course early. For instance, the 1,288 NCVPS eighth grade students represent 61% of the NCVPS population but only 5% of the total eighth grade population. Meanwhile, 27,455 eighth grade students took the course in a traditional classroom but represented only 17% of the traditional classroom population.

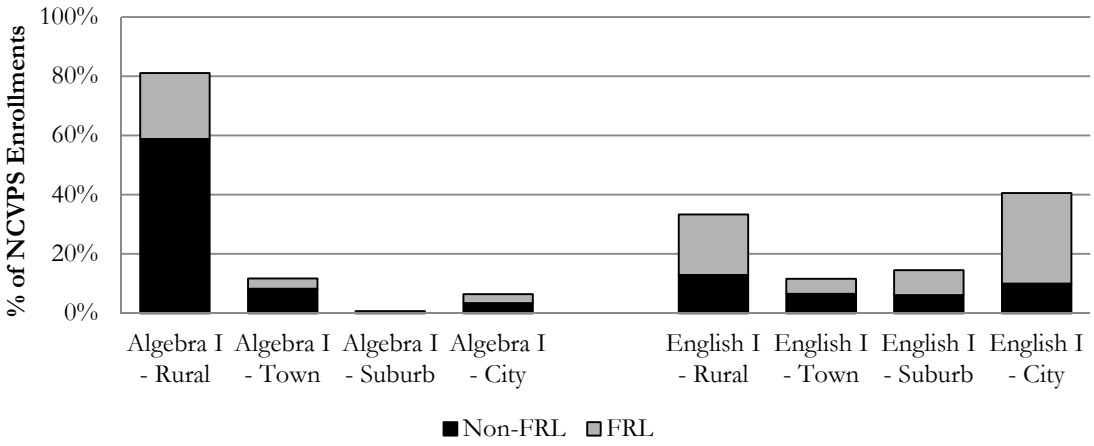
Most students take the course on time. Additionally, 25.1% of NCVPS students are late-takers (grades 10-12), compared to only 4.3% of traditional students. The proportions indicate that English I NCVPS students are more likely to be academically at-risk than traditional students. In these cases, NCVPS may serve as an *accommodation*.

FIGURE 3: DISTRIBUTION OF ENGLISH I STUDENTS BY GRADE



Rural students are over-represented in NCVPS Algebra I and under-represented in NCVPS English I, while the reverse is true of urban students. Moreover, FRL students are under-represented in NCVPS Algebra I and over-represented in NCVPS English I. Figure 4 displays the NCVPS enrollment by school location and student FRL status.

FIGURE 4: NCVPS ENROLLMENTS BY LOCATION AND FRL STATUS



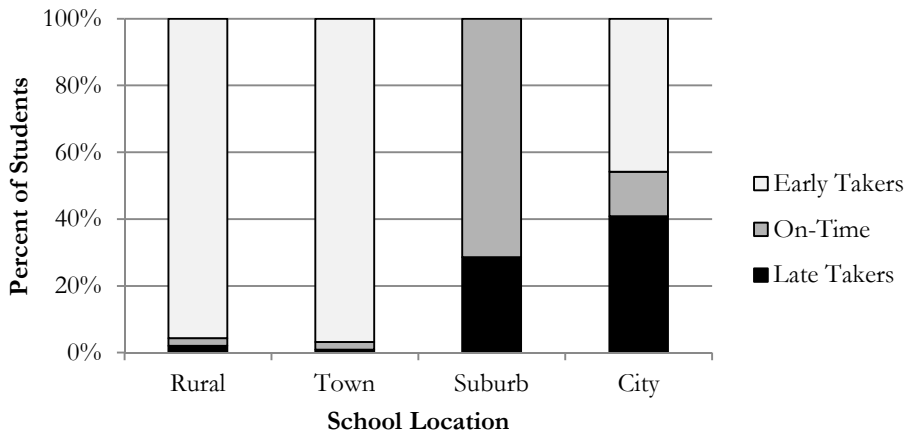
Recall that in North Carolina as a whole, about half of students are rural, about a quarter are urban, and the rest are split between towns and suburbs. Notably, non-FRL rural students make up nearly 60% of all NCVPS Algebra I enrollments. Again, NCVPS Algebra I may provide an opportunity for advantaged rural students, while English I provides an accommodation to less affluent students, particularly in cities.

B. STUDENT SORTING INTO NCVPS

Students may select into NCVPS for a variety of reasons. On one hand, some middle schools do not offer brick-and-mortar versions of high school courses such as Algebra I and English I. In particular, small rural middle schools may not be able to afford to offer high school courses, and NCVPS offers a chance for advanced students to pursue them. Such advanced students would likely outperform the state average, regardless of the method of teaching. On the other hand, many students need accommodations. Students may get sick, break a leg, or become pregnant. Other students may need to make up work to stay on track for graduation. These students systematically differ from average brick-and-mortar students and the advanced NCVPS students. They have a different propensity for success, and they may need extra support from their teachers.

This section examines the mechanisms through which students self-select into NCVPS. Figure 5 displays the breakdown of NCVPS Algebra I students by region and timing. Early takers are those students who take the course in eighth grade or earlier, while late takers are those who take it in tenth grade or later. In schools in rural areas and towns, most NCVPS students are early takers (95.6% and 96.8%, respectively). Providing a sharp contrast, 40.8% of NCVPS students in city schools are late-takers, while 45.8% are early-takers. No suburban students take the tests early,likely because suburban middle schools already offer traditional Algebra I options. Instead, 71.4% of the suburban NCVPS students are on-time takers, with the remaining students taking the course late.

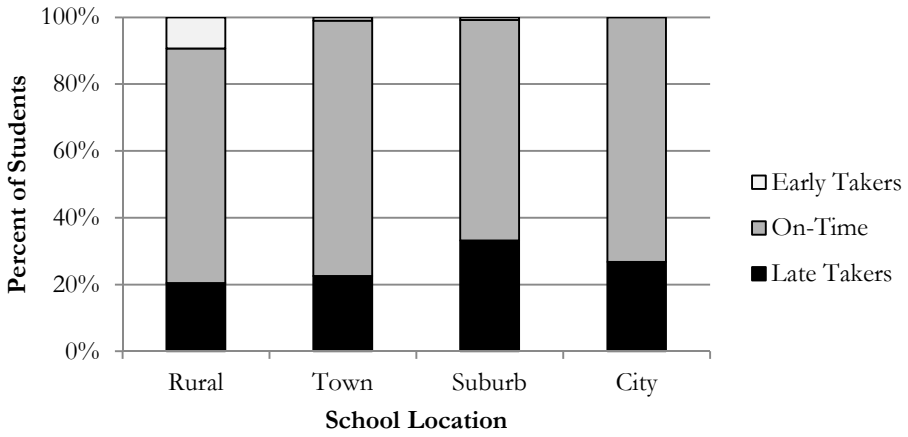
FIGURE 5: DISTRIBUTION OF ALGEBRA I NCVPS STUDENTS BY TIMING AND LOCATION



From Figure 4, 81.1% of all Algebra I NCVPS students are from rural schools, and most are not on FRL. From Table F2, Algebra I NCVPS students are also more likely to be in groups that generally succeed on standardized tests (early test-takers, non-FRL students, etc.). Rural schools also are more likely to have a limited range of courses (Sipple and Brent, 2008). Thus, it appears that the more affluent and academically proficient rural students use NCVPS to pursue high school courses not available in their local schools. These students use NCVPS as an opportunity. It remains unclear what forces drive Algebra I students to pursue NCVPS in later grades, as all high schools must offer these courses. However, these students more likely use NCVPS as an accommodation.

Figure 6 displays the breakdown of NCVPS English I students. The differences by region type are smaller than in Algebra I, but patterns remain. Of the few students pursuing English I in early grades, almost all attend rural schools. The percent of on-time takers ranged from 66.1% in suburbs to 76.5% in towns. The percent of late-takers ranged from 20.5% in rural areas to 33.2% in suburban areas. Thus, suburban schools appear most likely to have at-risk late-takers in NCVPS.

FIGURE 6: DISTRIBUTION OF ENGLISH I NCVPS STUDENTS BY TIMING AND LOCATION



From Figure 4, we know that rural students are under-represented in English I NCVPS. From Table F2, it appears that English I NCVPS students are also more likely to be in groups that generally struggle on standardized tests (nonwhite, LEP, etc.). The findings again indicate the notion of opportunities and accommodations.

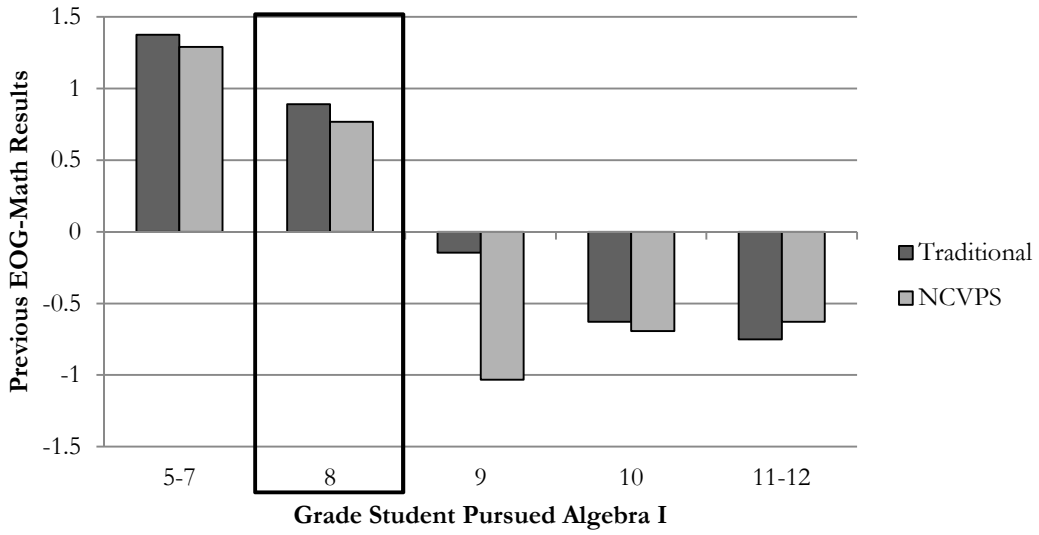
C. Previous Academic Outcomes of NCVPS and Traditional Students

Students' previous math and reading EOG test results provide an indicator for how they will subsequently perform in Algebra I and English I. For reference, **Appendix G** provides details on the cross-test correlation for Algebra I. Figure 7 and Figure 8 display the average scores for students' most recent EOG test by grade and course type for Algebra I and English I, respectively. The figures demonstrate that NCVPS students' past performances differ from those of traditional students, but the level of differentiation differs by grade level. The box indicates the most common grade level for a student to pursue NCVPS.

In Algebra I, traditional ninth grade students averaged -0.15 Z-scores on their most recent EOG-math test; NCVPS students averaged -1.03 Z-scores.[21] NCVPS students in grades 5-8 also underperformed relative to traditional students. The gaps are not functionally very large in these grades, but they are statistically significant. Thus, in the grade students most commonly pursue NCVPS, the students are fairly similar across both settings. The difference is not statistically significant in grades 10-12, partly due to the small sample size.

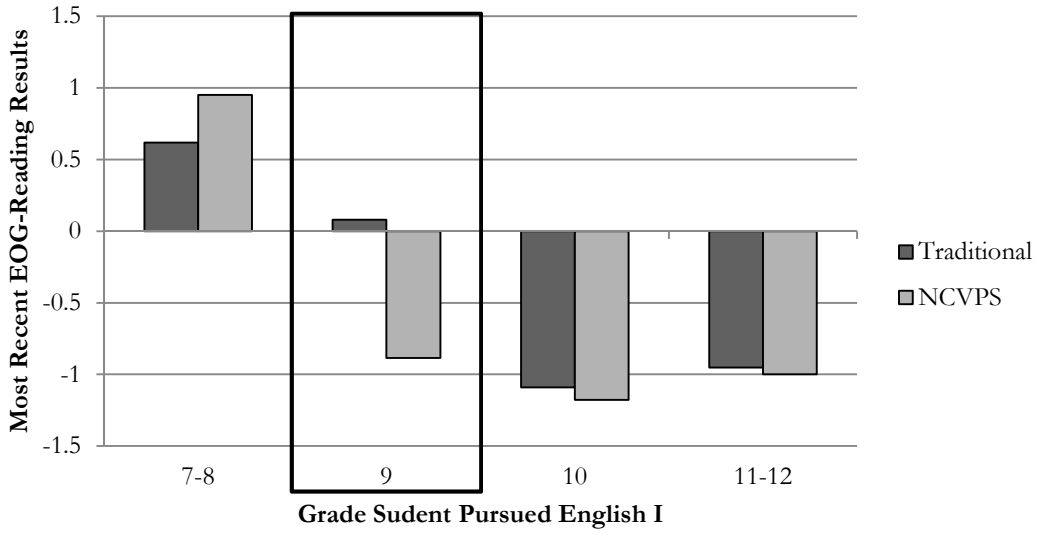
[21] Among traditional students, the negative average is driven by the number of students who take Algebra I early.

FIGURE 7: PREVIOUS MATH RESULTS BY GRADE FOR ALGEBRA I STUDENTS



In English I, ninth grade NCVPS students underperformed in the past relative to traditional students; the differences are not statistically significant in the other grades. Unfortunately, the large gap occurs in the year that English I students most commonly pursue NCVPS. For both Algebra I and English I, prior results indicate that NCVPS students have a lower propensity for success on EOC tests, but the differences is larger for English I.

FIGURE 8: PREVIOUS READING RESULTS BY GRADE FOR ENGLISH I STUDENTS



D. MULTI-YEAR ANALYSIS OF ACADEMIC OUTCOMES

The results on an EOC test are part of multi-year series of subject-specific courses. The following figures display a time-series of test results from the third grade EOG test to the EOC

test.[22] NCVPS ninth-grade students had consistently lower scores on previous EOG tests relative to traditional ninth-grade student in both courses (see Figure 9 and Figure 10, respectively).

FIGURE 9: MATH OUTCOMES OVER TIME OF 2010-11 ALGEBRA I NINTH GRADE STUDENTS

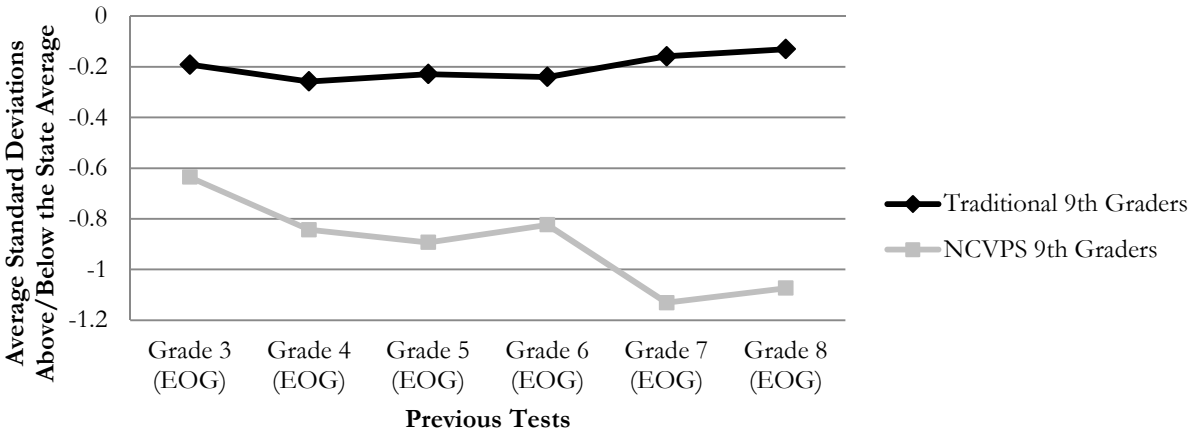
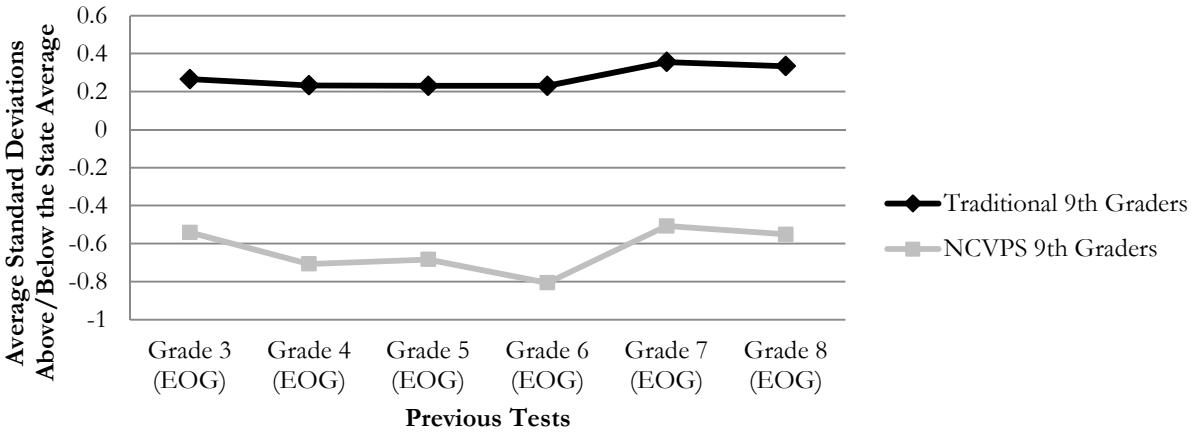


FIGURE 10: READING OUTCOMES OVER TIME OF 2010-11 ENGLISH I NINTH GRADE STUDENTS



Algebra I NCVPS students appear to have been on a downward trajectory even *before* taking an NCVPS course: the gap widened from 0.58 standard deviations in sixth grade to 0.94 standard deviations in eighth grade. Conversely, the English I NCVPS students improved from a 1.04 standard deviation gap in sixth grade to a 0.88 standard deviation gap in eighth grade.[23] Overall, the results indicate that the scores NCVPS ninth grade students achieved on their EOC tests may not result from the NCVPS system but may instead be part of a long-term trend.

[22] Earlier grades had a higher chance of missing data due to error or population movement. Students with missing scores in a particular grade are not included in the average for that year, but they are included for years when they have data. In Algebra I the data contained third grade scores for 76.8% of the population, compared to 80.0% of fourth grade, 83.1% of fifth grade, 86.0% of sixth grade, 85.6% of seventh grade, and 68.2% of eighth grade.

[23] Recall that only 66 ninth grade students used NCVPS for Algebra I, compared to 1,866 ninth grade students for English I. The low N limits the reliability of the pattern for Algebra I in ninth grade.

NCVPS eighth grade students in Algebra I had consistently lower EOG-math results compared to traditional eighth grade students (see Figure 11), while NCVPS English I students had consistently higher EOG-reading results (see Figure 12). The gap between groups remained fairly consistent in both course types. Recall that only 87 students took English I in eighth grade, compared to 1,288 students in Algebra I, which limits reliability of the trend for English I.

FIGURE 11: MATH OUTCOMES OVER TIME FOR 2010-11 ALGEBRA I EIGHTH GRADE STUDENTS

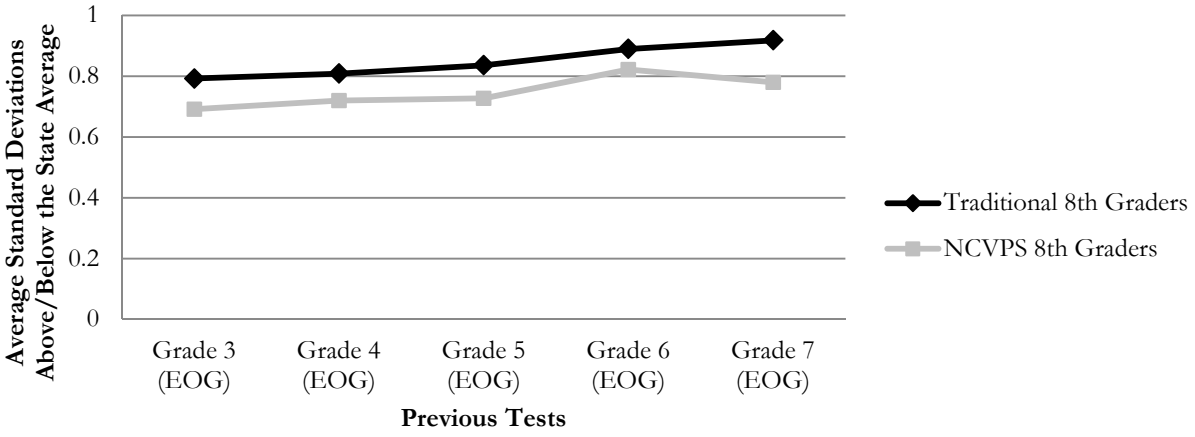
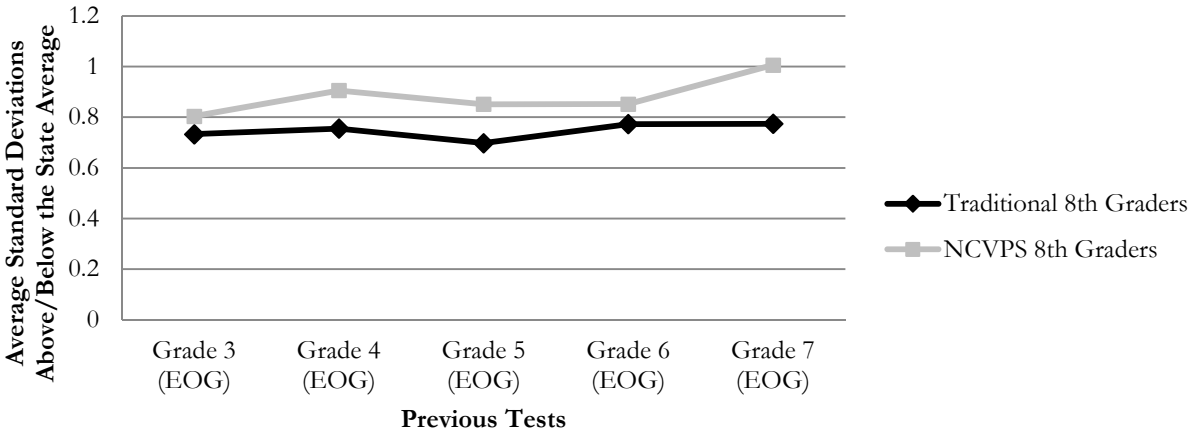


FIGURE 12: READING OUTCOMES OVER TIME FOR 2010-11 ENGLISH I EIGHTH GRADE STUDENTS



This section again demonstrates that the history and characteristics among NCVPS students differ from those of traditional students. The students' previous academic performance provides further insight into why NCVPS and traditional students may perform differently.

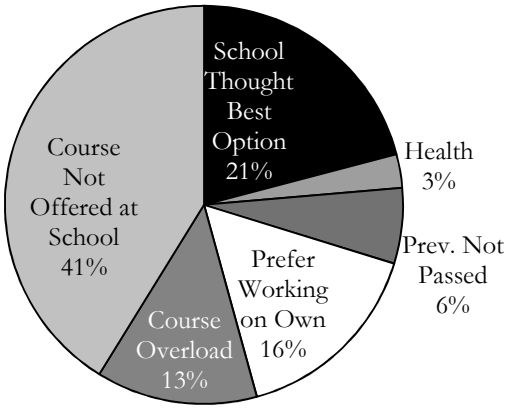
E. NCVPS Student Survey

To examine the motivations behind sorting, I sent a survey to all students in a spring 2012 NCVPS course (see **Appendix D** for a full list of questions). Given my project timeframe and the survey anonymity, I cannot match student EOC test results to student responses on the survey. However, beginning to understand how and why students selected NCVPS in 2011-12 may provide insight into some of the 2010-11 results.

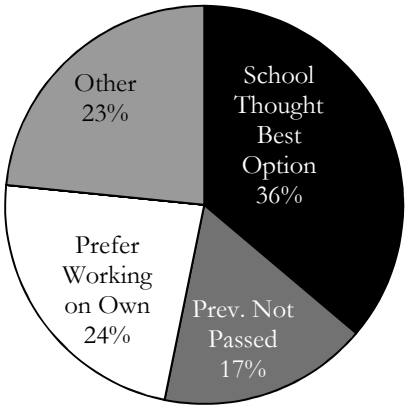
A total of 3,784 students responded to the survey out of a total of 21,912 who took an NCVPS course in the spring of 2012 (a response rate of 17.3%). Of these, 147 took Algebra I course and 47 took English I, while 19 students took both (response rates of 51.8% and 41.6%, respectively). Most students were female (66.1%) and white (36.3%). The average grade level was 10.6, although 11.2% of students were in middle school. The survey asked students about a variety of aspects of their experience with NCVPS. The students answered the questions in the first few weeks of the spring semester, and students in semester-long courses had little experience in NCVPS.

FIGURE 13: NCVPS STUDENTS' REASONS FOR PURSUING A VIRTUAL COURSE

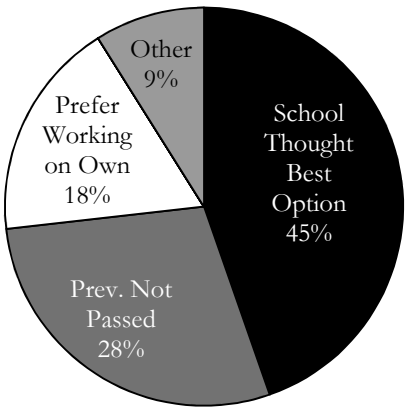
All Courses (Sample Size: 4,603)



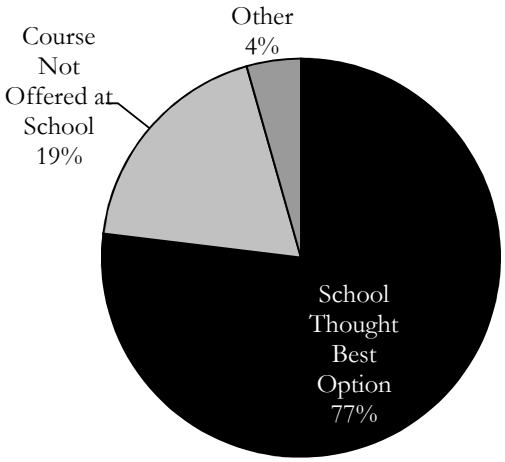
High School English I (Sample Size: 47)



High School Algebra I (Sample Size: 56)



Middle School Algebra I (Sample Size: 91)



Students pursued virtual education for a variety of reasons, as displayed in Figure 13.[24] The reasons differ by grade level and course, and these patterns may provide insight into how students

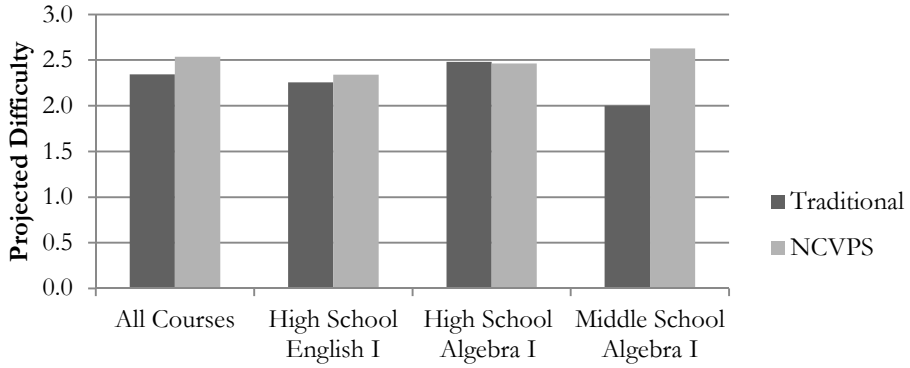
[24] The survey asked students, *"What best describes your reason for taking this course online?"*

sort into the virtual environment. Across all courses, 41% of students indicated that the course was not offered at their school, while 21% said the school thought it was the best option and 16% preferred working on their own. Very few students pursued NCVPS primarily for health reasons.

All high schools offer English I and Algebra I, and for these courses the students were divided between the school thinking it was their best option, re-taking the course, and a preference for working on their own. Few middle school students indicated their reason for pursuing NCVPS was a preference for working on their own; instead a school's urging and a lack of course offerings drove young Algebra I students into NCVPS. It's unclear whether the school thinking it was the best option *also* meant the course was not offered at the school (and vice versa). This does not indicate whether middle school students would prefer a traditional classroom, but it does seem like they may not have a choice in the matter if they want to pursue Algebra I.

Students reported a variety of ways that people encouraged them to pursue NCVPS; **Appendix D** includes sample comments.[25] Middle school Algebra I students indicated that their teachers and parents praised their intelligence and reasoned that they could get ahead in high school. High school students said teachers and principals promoted flexibility and staying on track for graduation. However, many students at all levels indicated that their schools did not give them a choice in the matter, and many students voiced dissatisfaction with the situation.

FIGURE 14: NCVPS STUDENTS' PROJECTED DIFFICULTY OF TRADITIONAL AND NCVPS COURSES



Some courses are more difficult than others. How would you rate the expected difficulty?

Next, I compared students' views of the difficulty of NCVPS courses relative to traditional courses using a four-point Likert scale ranging from one (least difficult) to four (most difficult).

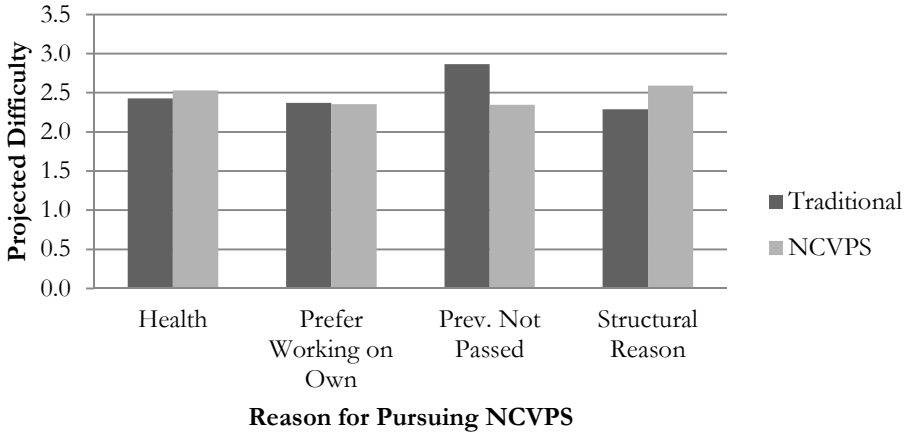
[25] Students responded to the prompt: *"Please describe how people encouraged you to try virtual schools."* The survey also asked, *"Who most encouraged you to take a course through NCVPS?"* and *"Who most discouraged you to take a course through NCVPS?"* Guidance counselors/other administrators most frequently encouraged participation; 38.8% of students selected this response. Parents were the next most encouraging group at 17.3%. About 17.9% of students reported that their parents, teachers, or guidance counselors most discouraged them from pursuing NCVPS; 20.6% of students reported their friends were most discouraging. The remainder of students (61.5%) selected Other/Not Applicable for discouragement. This may imply two things: that parents, teachers, and guidance counselors successfully kept students with a low propensity for success out of NCVPS, or that few people discourage students from pursuing the system.

Figure 14 displays the results.[26] It seems likely that students who actually take NCVPS would believe it will be easier than students who do not, particularly before coursework begins. Instead, the reverse is true: students reported higher anticipated difficulty level in NCVPS. The difference is statistically significant. Of course, numbers on a scale have little meaning on their own. A report of two may mean something different to each student. However, the power of the scale comes from the *relative* rankings, both within students/across settings and across students/within settings.

Focusing specifically on English I and Algebra I students, the difference was statistically insignificant for the high school students, indicating that these students thought the course would be equally difficult in either setting. However, middle school students thought the NCVPS course would be substantially harder than the same course taken in a traditional classroom.

Recall that middle school students do not appear to actively pursue NCVPS; rather, their school's advice or lack of a course led them to the virtual system. Across all students, those that pursued NCVPS for personal reasons (health problems or a preference for working on their own) reported NCVPS and a traditional course would be about the same level of difficulty (see Figure 15). Students who had previously not passed the course (presumably in a traditional classroom) report that NCVPS will be easier. A different pattern emerged among students who used NCVPS due to a structural aspect of their school, namely schools not offering the course, students wanting to take more classes outside the school day, or schools thinking NCVPS was the best option for the students. Those students reported that NCVPS would be harder than the traditional classroom, which implies that students who choose between taking the course online or not taking it at all believe it will be more difficult in NCVPS. Depending on student preference for class difficulty, this may also indicate that certain students prefer the traditional classroom.

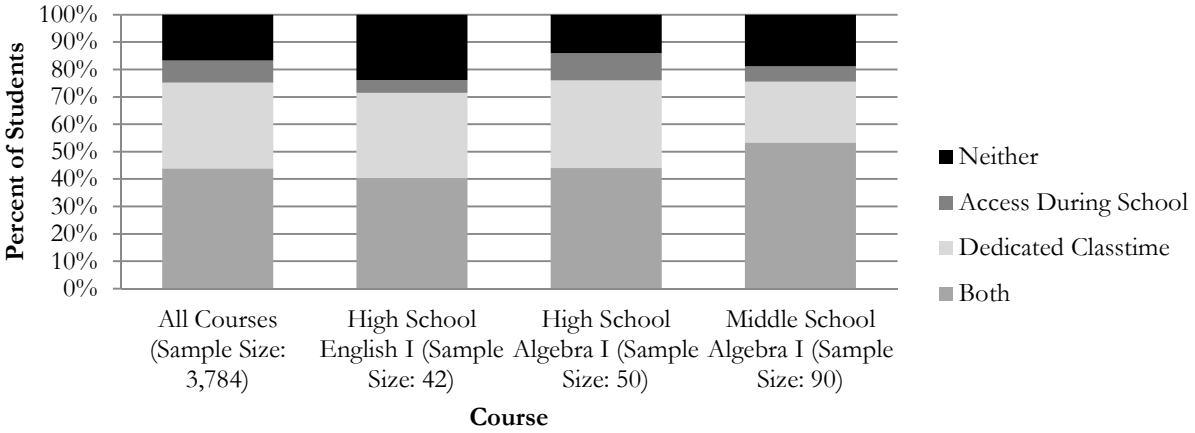
FIGURE 15: NCVPS STUDENTS' PROJECTED COURSE DIFFICULTY BY PURSUIT REASON



[26] The question specifically asked: *"Some courses are more difficult than others. How would you rate the expected difficulty of the following courses: (1) This course, taken through NCVPS (2) This course, taken in a regular classroom."* This question allows a relative comparison of the expected difficulty for the students who took NCVPS, but it did not provide the view of NCVPS by students in general.

Students worry about a variety of aspects of the virtual system. Middle school students worry about not having a teacher in front of them, with several students also mentioning technology crashes as a potential problem. High school students are more concerned about technology glitches, falling behind, and failing the course or the EOC test. Despite potential concerns, many students indicated they were looking forward to their courses for a variety of reasons. They frequently reported that they like technology and working at their own pace, and middle school students also looked forward to getting high school credit out of the way. Several high school students also reported that their friends or others said NCVPS would be easier than the regular classroom. One student mentioned avoiding bullies, while others reported being distracted in traditional classrooms. Overall, the responses indicate that opinions on NCVPS differ widely across students. **Appendix D** displays several representative comments.

FIGURE 16: STUDENTS' NCVPS ACCESS DURING SCHOOL HOURS



Students frequently reported worrying about completing assignments on time. While about 35% of all students reported being either "Somewhat Worried" or "Very Worried" about their ability to complete their work, 50% of middle school Algebra I reported the same concerns.[27] The time students have available to work on their coursework may cause some of this concern. Figure 16 displays the NCVPS access that students reported they have available during the school day.[28] Access includes a dedicated class period for their course, computer access during school hours, or both, and 75% of students report having dedicated class time available across all courses. The percentages range from 71% for high school English I students to 76% for both Algebra I groups. However, a full 24% of high school English I and 19% of middle school Algebra I students have no

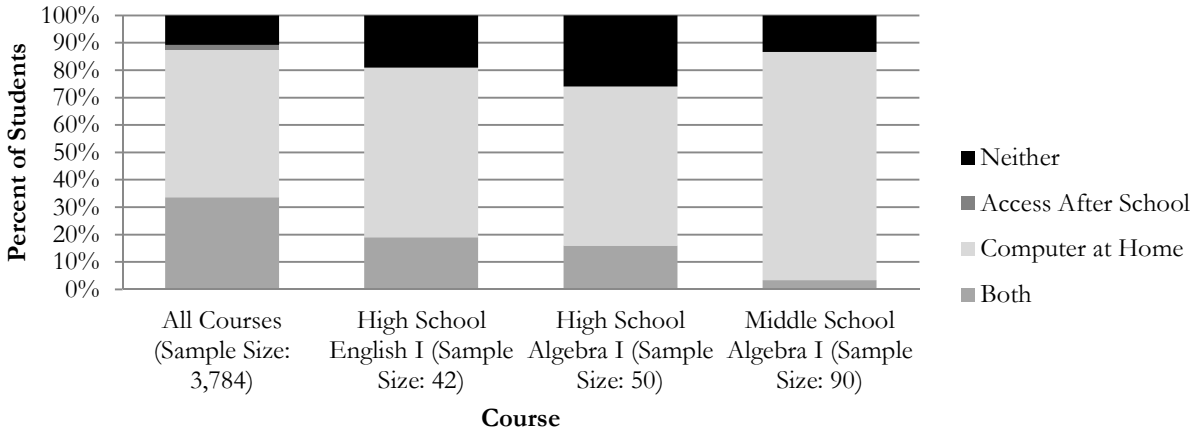
[27] About 45% of high school English I and Algebra I reported worries. For the question *"How worried are you about being able to complete your assignments and work in a virtual course?"*, students could answer "Not Worried at All," "Only a Little Worried," "Somewhat Worried," or "Very Worried." Reported percentages are for the latter two categories.

[28] For the question *"What sort of support will you have as you take courses on NCVPS?"*, students could answer "I have class time and computer access dedicated to this course during normal school hours," "I have access to a school computer lab during school hours," "I have access to a school computer lab after or before school hours," "I have a computer at home," or "Other" with an optional description.

reported access to NCVPS during their school hours; this lack of time may contribute to their concerns about the virtual environment.

If students do not work on NCVPS during the school day, they must do so after school. Figure 17 displays the access that students reported they have available after school hours in the school computer lab, at home, or both. Overall, 88% of students report having a computer at home; the percentages range from 81% for high school English I to 87% for middle school Algebra I. Importantly, 11% of students report having no access to a computer after school hours. Even with a dedicated class period for NCVPS, these students will likely have homework that requires work outside the school day. Students reported a variety of solutions, including the public library, their smartphones, or a friend's house. One student said, "I try to use my grandma's computer at her house." Another said simply "I don't know." Many students indicated that their school provided them with computers, but several had no internet at home. Thus, technology access may hamper some students' success, and schools may need to use more caution as they determine which students should pursue NCVPS.

FIGURE 17: STUDENTS' NCVPS ACCESS AFTER SCHOOL HOURS



Results indicate that certain students are very happy with NCVPS; an eleventh grade student taking a Mandarin language course noted, "NCVPS has been a great help in letting me to take classes in order to get credits, get ahead, and take classes I normally wouldn't be able to take." Still, some students appear to be unhappily forced into the system. Going forward, policymakers should carefully consider how students end up in the system and what sort of support they receive.

F. Section Summary

Students are not randomly assigned to NCVPS; rather, their parents, their schools, and the students themselves make a choice to pursue virtual education. This section demonstrates that NCVPS students differ from their traditional peers in observable ways, and it is likely that students who opt into NCVPS differ in unobservable ways as well.

As a descriptive exercise, the results provide interesting insights for DPI, NCVPS, and local schools. More specifically, results indicate the following:

- NCVPS students differ substantially from traditional students. Policymakers cannot directly compare the performance of NCVPS and traditional students due to these differences.
- Certain high-performing students use the system as an opportunity to take classes that would be otherwise unavailable, while at-risk students use NCVPS as an accommodation to stay on track for graduation.
- Given the types of students who take Algebra I and English I on NCVPS in high school, the state may need to provide more support than it currently does. Although I cannot say how they would perform in a traditional classroom, many students clearly appear to struggle in NCVPS.
- Certain middle schools do not give some students a choice about the virtual system, and some students prefer a traditional classroom. Policymakers should weigh the extent to which student preferences should affect NCVPS expansion.

In the next section, I examine the effectiveness of NCVPS using a variety of statistical designs that compare test scores between middle school students who only have NCVPS in their school to middle school students who only have a traditional model available.

VI. How Effective Is NCVPS?

Selection bias is a major concern in any effort to determine the effectiveness of NCVPS. Students are not randomly assigned to the NCVPS treatment or the traditional course control, and students can choose the type of education they pursue in most cases. In high schools in particular, students may choose the option that suits them best. To accurately measure the impact of NCVPS on students' academic outcomes, I need to examine differences in student performance for those who do not *choose* their type, such as those students who have no choice in their type of Algebra I education. Specifically, over 1,100 students pursued an Algebra I course in one of sixteen schools where most students taking the Algebra I EOC used the NCVPS platform. This section compares these students to similar students in traditional classrooms. Part A explores the restricted data set that I use in the analysis. Parts B, C, and D describe the analytical frameworks and results for three separate but related analyses: Ordinary Least Squares (OLS), propensity score matching, and a longitudinal panel. Finally, Part E provides a section summary.

Results across all three methodologies indicate that eighth grade students perform about the same in NCVPS as they would have in the traditional classroom. Very early takers, defined as those who pursue NCVPS Algebra I in seventh grade or earlier, perform worse than similar eighth graders, holding all else constant. Further, NCVPS students perform worse than similar traditional students among these very early takers.

A. DESCRIPTIVE STATISTICS

A total of 1,145 Algebra I NCVPS students attended one of the sixteen schools where 95% or more of students used the virtual system for their online learning. Because North Carolina requires high schools to offer Algebra I, this situation occurs only in middle schools, defined as schools offering grades 6 – 8. I limit my control group to middle school students where 0% of students used NCVPS for Algebra I. I could not complete a similar analysis for English I, as too few middle school students used the virtual system. Because I used middle school students, the population will be positively selected from the overall population. Though results will not necessarily generalize to the total population of Algebra I students, they will apply to advanced middle school students.

Table F3 in **Appendix F** displays a bivariate analysis of the limited Algebra I population for very early takers (below eighth grade) and eighth grade students.[29] There are 28,264 students in the full sample of Algebra I takers in middle school. Of this total, 1,145 are NCVPS students (278 very early takers and 867 eighth graders) and 27,139 are traditional students (2,760 very early takers and 24,379 eighth graders). Students in this limited sample have better EOC test results than the statewide population, as expected for a positively selected group taking the course before the typical student. Compared to the statewide average from Table F1, the limited population has more gifted students and fewer nonwhite, EC, FRL, and LEP student. Again, this distribution is as expected for a positively selected group.

Two conflicting stories emerge about the NCVPS students in the restricted sample: a relative advantage demographically and a relative disadvantage academically. The NCVPS group has a smaller proportion of nonwhite, FRL, and LEP students, and these students attend schools that are less nonwhite and less poor. However, the NCVPS students have lower performance on their most recent EOG. It remains unclear how these differential factors affect students' Algebra I outcomes.

Notably, 83.8% of NCVPS students hail from Johnston County, where seven of the sixteen NCVPS schools are located. NCES classifies Johnston County Schools as rural, but its adjacency to the city of Raleigh in Wake County means that its northwestern region is rapidly urbanizing. Several other counties are similarly growing and urbanizing: Chatham County outside of Raleigh; Cabarrus and Iredell Counties outside of Charlotte; and Brunswick County outside of Wilmington.[30] Students in these counties have higher Algebra I test scores, Algebra I passing rates, and previous EOG-math test scores than other counties. Students in these counties are also more likely to be white, not on FRL, academically/intellectually gifted, proficient in English, and attend schools with fewer FRL and non-white students.

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[29] Table F1 provides a reference for the statewide average.

[30] These counties (including Johnston) are all classified as rural by the NCES statistics. I classified a county as urbanizing if its ten-year growth rate to 2010 fell within 10 percentage points of Johnston County (ranging from 29.3 in Chatham County to 47.9% in Brunswick County) and their projected populations exceeded 60,000 people (North Carolina State Demographer, 2011). Only Union County near Charlotte had higher growth and a large enough population, but its very high average income was an outlier among the selected counties.

The NCVPS students come from more advantaged backgrounds and schools, and these students and schools are located in rural areas that are quickly becoming suburban. Next, I describe various statistical methods I used to analyze the data. To read a summary of results without the statistical details, please skip to the section summary on page 25.

B. Ordinary Least Squares Analysis

1. Analytical Framework

I use the North Carolina Algebra I EOC test to compare how similar students perform in NCVPS and traditional classrooms. In randomized experiments, results of the treatment and control can be compared directly because their component units are likely similar. In non-randomized studies, the units may differ systematically between the treatment and control groups. The previous sections clearly demonstrate such differences, indicating that a statistical model should control for those student characteristics. To do so, I employ several progressively more comprehensive statistical models. The baseline model is:

EQUATION 1

$$score_i = \alpha + \beta_1 NCVPS_i + \varepsilon_i ,$$

where score is the standardized test score for student *i*, α is the constant, NCVPS is an indicator variable of whether the student took the course through NCVPS, and ε is the error term. Thus, β_1 is the average test score difference between NCVPS and traditional students, and in this baseline regression the estimate will equal the average differences displayed in the first row of Table F3. This and subsequent regressions cluster the standard errors by school.[31] To control for additionally differences by student characteristics, I progressively add control variables:

EQUATION 2

$$score_i = \alpha + \beta_1 NCVPS_i + \beta_2 PriorPerformance + \beta_3 Student_i + \beta_4 School_i + \varepsilon_i ,$$

where PriorPerformance is a series of indicator variables for each decile of performance on student *i*'s most recent EOG math exam.[32] An additional indicator variable denotes missing previous test results. Student is a vector of indicator variables of student characteristics (grade, sex, race/ethnicity, ESL status, EC status, AIG status, and FRL status),[33] and School is a vector of variables of student *i*'s school characteristics (charter status and percent FRL in a school).[34] For this equation, β_1 represents the difference between NCVPS and traditional students, holding prior performance, individual-level characteristics, and school-level characteristics constant. I do not

[31] Students in the same school share similar academic, economic, and social environments, and the error term is likely correlated within schools (see discussion in Moulton, 1986).

[32] See **Appendix G** for details on correlations across math tests.

[33] Prior performance captures most of the control characteristics, because, as an example, the earlier scores are also influenced by race, sex, and other factors that do not change. However, I keep the vector of individual controls to account for any effects resulting from the shift to a high school course and the shift from more general EOG tests to a subject-specific EOC test.

[34] Percent FRL and percent nonwhite in a school are highly collinear in this model, and only one should be included.

include school location variables because the status does not differ within NCVPS students. Thus, the coefficients would only capture differences within the control population.[35] Finally, NCVPS may provide a better or worse option at different stages of student development. I thus add an interaction, as follows:

EQUATION 3

$$score_i = \alpha + \beta_1 NCVPS_i + \beta_2 PriorPerformance + \beta_3 Student_i + \beta_4 School_i + \tau(NCVPS_i * Early_i) + \varepsilon_i,$$

where $NCVPS_i * Early_i$ is an interaction between NCVPS and whether the student took the course very early, defined as seventh grade or earlier. Thus, β_1 will provide the estimated average difference between NCVPS and traditional courses in eighth grade, and τ will indicate divergences from this pattern for seventh grade and younger students, holding all other included variables constant.

2. RESULTS

Table 1 below displays a summary of the NCVPS, grade, and interaction coefficients; Table F4 in **Appendix F** displays the full Algebra I OLS regression outcomes. The first column displays the result for the baseline regression; this result (β=-0.053 standard deviations) matches the simple comparison of averages from Table F3. The results are not statistically significant when the errors are clustered at the school level.

TABLE 1: SUMMARIZED OLS REGRESSION RESULTS

	General Analysis					*Urbanizing Analysis*	
	(1) Z-Score	(2) Z-Score	(3) Z-Score	(4) Z-Score	(5) Z-Score	(6) Z-Score	(7) Z-Score
NCVPS	-0.053	-0.010	0.003	-0.033	0.036	-0.008	-0.042
	(0.075)	(0.030)	(0.027)	(0.031)	(0.027)	(0.038)	(0.051)
Grades 5-7			-0.164***	-0.160***	-0.137***	-0.134***	0.146
			(0.034)	(0.033)	(0.032)	(0.032)	(0.078)
NCVPS*Grades 5-7					-0.297***	-0.310***	-0.561***
					(0.088)	(0.088)	(0.118)
Restricted to Urbanizing?	NO	NO	NO	NO	NO	NO	YES
N	28,284	28,284	28,284	28,284	28,284	28,284	1,986
R^2	0.0002	0.4961	0.5206	0.5252	0.5262	0.5263	0.4677

Controlling for past performance, the results in the second column imply that NCVPS students score 0.010 standard deviations lower than the traditional students, though the difference is not statistically significant. Adding the individual-level characteristics modestly changes the coefficient on NCVPS (β=0.003 standard deviations), but again the coefficient is not statistically significant.[36] Very early takers (grades 5-7) perform worse than other students with similar

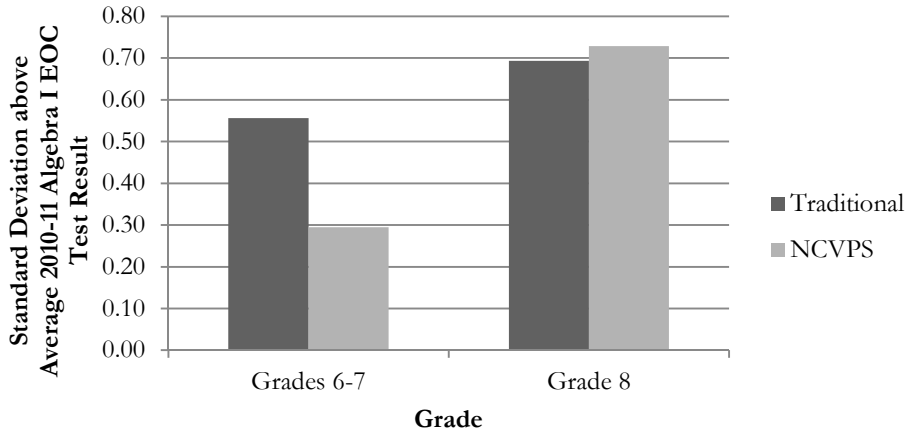
[35] Further, the "rural" construct may not capture the nature of a school as well as percent FRL does. Rural status is the same between a mountain school far from any suburban hub and a less remote school close to the expanding suburbs. Additionally, strata without observations in both the treatment and control will not count towards estimating β_1. , including the location variables does not change the results.

[36] Females and academically/intellectually gifted students perform better than otherwise similar students, while exceptional children and FRL students perform worse. The coefficients for nonwhite and LEP status are not statistically significant. Note that throughout much of academic literature females and nonwhite students perform worse in math

individual characteristics by about 0.164 standard deviations.[37] In other words, if an eighth grade student and a seventh grade student have matching previous EOG-math scores and other characteristics, the model implies that the seventh grade student will not perform as well in Algebra I. Including the school-level characteristics in column (4) does not substantially change the results; the difference between NCVPS and traditional students is -0.033 standard deviations, which is not statistically significant.

A more complicated pattern emerges when the estimated effects are allowed to differ by grade in Column (5). The control coefficients remain about the same as in previous regressions. Figure 18 summarizes the results for a typical student by grade.[38] NCVPS students perform about the same as traditional students in eighth grade (*p*-value=0.190). The model implies that very early takers in traditional classrooms perform about 0.137 standard deviations below similar traditional eighth grade students. Tests on the coefficients suggest that very early-takers perform worse than both similar eighth grade NCVPS students and similar seventh grade traditional students. The gap between seventh and eighth grade NCVPS students is about -0.434 standard deviations (*p*-value=0.000), while the gap between seventh grade NCVPS students and seventh grade traditional students is about -0.261 standard deviations (*p*-value=0.000).

FIGURE 18: REGRESSION ESTIMATES FOR THE FINAL OLS REGRESSION



3. SENSITIVITY ANALYSIS

I perform several checks to verify the OLS results. First, columns (6) and (7) in Table 1 above and Table F4 in **Appendix F** present the results for two methods of controlling for urbanizing schools. Controlling for urbanizing status in column (6) does not substantially affect results or improve the model fit. Similarly, when limiting the analysis to *only* the urbanizing districts,

---

than males and white students, respectively. The results are interesting in that controlling for other factors eliminates or reverses these expectations.

[37] These results align with previous research on North Carolina very early takers (Clotfelter, Ladd, and Vigdor, 2012).

[38] A typical student is a rural male that has no AIG, EC, FRL, or LEP status with an EOG score in the fifth decile and attending a school with 50% FRL students. A typical student is displayed as an illustrative example; the model predicts the general trend to hold across all student types.

NCVPS eighth graders, traditional eighth graders, and traditional very early takers perform about the same, but traditional very early takers outperform NCVPS very early takers by about 0.561 standard deviations (p-value=0.000). The reduced number of observations limits the accuracy of the model, but again, results imply that otherwise similar very-early takers do not perform as well in NCVPS.[39]

NCVPS students may differ from traditional students in *unobservable* ways. If this is the case, students' previous test results may differ in *observable* ways. Moreover, the 2010-11 decision to pursue NCVPS may retroactively "predict" performance on prior exams. However, a verification strategy that replaces the Algebra I EOC standardized test score with the students' fifth grade math standardized EOG results found no statistical difference between NCVPS and traditional students in either the very early takers or the eighth grade students.[40]

I also use a variety of more advanced statistical methods to address the data in additional ways. **Appendix H** explains the methodologies and results. Using both a propensity score matching and a panel data approach, I confirm that eighth grade students perform about the same in both settings. Among very early takers, NCVPS students consistently score between 0.25 and 0.30 standard deviations lower than similar traditional students.

Finally, a review of the interaction between NCVPS and various control variables finds no indication of causal effect heterogeneity by previous math scores, FRL status, or nonwhite status.

C. Section Summary

A variety of statistical methods consistently find that eighth grade NCVPS students perform about the same in NCVPS or the traditional classroom, while very early takers perform about 0.25 standard deviations worse in NCVPS relative to traditional students. The results are consistent for a variety of specifications and robustness checks. Still, selection bias may remain a concern in the analysis. All students taking Algebra I in middle school have made a choice to pursue a high school course in an early grade; the choice may be different in NCVPS and traditional schools.

If I used only demographic characteristics, I may indeed miss unobservable differences and allow for selection bias. However, the use of previous math test results uses students' demonstrated academic proficiency (and, in the case of panel data, their entire history of math exams) to predict their Algebra I performance. If a bias remains, the analysis somehow missed a systematic advantage or disadvantage that NCVPS students have over traditional students. If this were the case, and NCVPS students were disadvantaged relative to traditional students in some unobservable way, then one would expect that observably similar students would perform worse in NCVPS than the traditional classroom.

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[39] N=1,986 total, including just 297 very early takers.

[40] I use the fifth grade EOG-math test results because it limits co-linearity with the *most recent* EOG-math exam among seventh grade students. If I used the sixth grade results, the most recent EOG-math exam would perfectly predict the score for seventh grade students.

One could argue for this case. Although the students in the treatment schools cannot choose NCVPS or a traditional education, the schools themselves have made a decision to offer one option or the other. This systematic difference may signal differing budgets or parental influences. The schools using NCVPS may have no other option, whereas traditional schools in less remote or more affluent locations may have been able to choose the brick-and-mortar option. Given the relative newness, cost, and middle school students' reported opinions of NCVPS, it seems reasonable to believe that NCVPS is a "second choice" to a traditional classroom for most schools. Rural schools continue to struggle to attract and retain high-quality teachers (Ingersoll, 2001; Sipple and Brent, 2008), and NCVPS offers one solution. Thus, eighth grade students in NCVPS may succeed despite potentially negative, unobserved influences.

Alternatively, NCVPS students may be advantaged relative to traditional students in the treatment group. For instance, perhaps only the best and brightest of students who would take middle school Algebra I in a traditional classroom pursue it when presented with NCVPS. Though I find no difference in previously demonstrated ability, perhaps the difference lies in unobservable characteristics. In this case, NCVPS students may appear to perform better than they actually would have in the traditional setting. No statistical controls can account for this difference, but given the wide variety of individual, school, and district characteristics that the models control, it seems improbable that this occurs.

Moreover, standardized tests may provide systematic bias between groups. For example, students accustomed to taking assessments online for NCVPS may have trouble adjusting to paper tests for the Algebra I EOC, which could mean their test scores underestimate their ability and content knowledge. Alternatively, one group or the other could have more EOC test prep prior to the EOC test. I do not expect the difference to be large, but it may exist. Additionally, standardized test scores are only one measure of student learning. NCVPS students may gain additional computer skills, study skills, and discipline from taking the class that traditional students may not receive. Traditional students may have more beneficial peer-to-peer interaction. Thus, even though students may earn the same score, other forms of learning could differ.

VII. Conclusion

My research examines the EOC test outcomes of middle school Algebra I students, as well as high school students in Algebra I and English I to a limited extent. Based on the present analysis, it appears that positively selected, motivated students can perform about as well as traditional students in Algebra I. These results are a first step in confirming that students in a virtual environment can perform as well as students in a traditional classroom. Math-based courses are a logical place to begin analyzing virtual courses, as they require less interaction than other types of courses. It remains to be examined whether or not these outcomes generalize to less able students or courses that require more discussion or hands-on learning.

Two types of students appear to use NCVPS: (1) those using it as an opportunity to take an overload of courses or to pursue a subject not offered at a school and (2) those using it as an

accommodation for staying on track for graduation. Each group has specific needs. Based on my research, I offer the following policy recommendations:

1. *Rural middle schools without the capacity to offer a traditional Algebra I course should allow advanced eighth grade students to take the course through NCVPS.*

   Controlling for a wide variety of background characteristics, high-performing Algebra I students using NCVPS as an opportunity appear to perform about as well as their peers in traditional classrooms in eighth grade. Virtual Algebra I courses offer an attractive option for small schools seeking to provide the courses to interested and motivated students.

   Although more research is needed, this finding may also extend to advanced students in other subject areas. For instance, perhaps a school should allow a student with a demonstrated ability in foreign languages to pursue a Mandarin or Arabic class virtually if they do not offer the course locally. On a related note, schools should also allow advanced students to use the virtual option to take an overload of courses if they are deemed capable of handling the additional work.

   Policymakers need to balance student preferences with the potential cost savings and expanded offerings that virtual education offers. Middle school students in particular indicate that they prefer a traditional classroom to the virtual environment.

2. *NCVPS does not work for all students, and certain students need special support.*

   Advanced eighth grade students represent a unique student type, and policymakers must use caution before expanding access to less academically proficient or motivated students.

   My research consistently found that very young students using NCVPS as an opportunity in sixth or seventh grade fare poorly in Algebra I. Some students may not be ready academically or developmentally to use a self-directed virtual program, and in these cases it may benefit young students to wait a year or two before pursuing NCVPS. Alternatively, perhaps the teaching style of the virtual environment is geared towards later grades. More research is needed in this area.

   Additionally, many students that pursue NCVPS use the system as an accommodation to, for instance, stay on track for graduation. In particular, urban districts tend to place less affluent students with poor prior performance in NCVPS. My research can only provide a descriptive analysis of these students, and I cannot say with certainty how at-risk virtual students would fare in a traditional classroom. It may have been better, worse, or about the same. However, these students have a history of academic struggles, meaning they likely need an entirely different support system than advanced, high-achieving eighth grade students. Currently, teachers can

differentiate instruction among the students, but these two very different students types with very different needs may be placed in the same virtual classroom. NCVPS should consider this balance as they assign students to classrooms, and more research should focus on what particular methods and means of support work best for at risk students in the virtual environment.

Ultimately, policymakers may need to balance students' understanding of the material with their need to stay on track for graduation. School, district, and state policymakers need to ask several questions: Does a student with a history of struggling academically have the maturity and self-direction necessary to succeed in NCVPS? If a student has come to the point where they need to take an overload of courses to graduate on time, then is this the sort of student who will likely succeed with the academic pressure of a course overload? Is getting a course "out of the way" better than ensuring that students fully understand the material? These are questions that may have unique answers for each student, and a blanket policy one way or another may not be appropriate. However, NCVPS should urge schools to use caution as they assign at-risk students to the virtual system.

Notably, I did not specifically examine the "credit recovery" option for students who have previously failed either English I or Algebra I. Instead, I focused on students who took the course designed for students pursuing the subject for the first time.

3. *School and state policymakers must stay up-to-date with technology needs and advances.*

Schools should employ better screening to ensure that students have access to the technology they need to succeed in NCVPS. Over 10% of NCVPS students reported having no computer at home, and additional students did not have internet access. This may disproportionately affect less affluent students, and policymakers need to consider ways to address the problem. Almost certainly, these students are not set up for success if they cannot access their course content at home.

Additionally, student survey responses indicate that students prefer the support, guidance and physical presence of a traditional classroom. To some extent, students must adjust to the virtual environment, and the academic success that many virtual students demonstrate shows that they can. However, NCVPS could also do more to support students learning needs. Currently, the virtual course involves PowerPoint lectures that students can read at their leisure and a series of quizzes that students can retake as many times as they want. Students can interact with their teachers in a variety of ways, including daily chat room office hours, instant messaging systems, message boards, text messages, and phone calls. As technology moves forward, NCVPS should learn from best practices of other systems. For instance, perhaps NCVPS could supplement the PowerPoint slides with a standardized video lecture

> that can be used by all teachers year-after-year.[41] The teacher will still interact with students with the methods mentioned above, but a video lecture of an effective teacher manually working through a problem or topic may be more beneficial than a series of PowerPoint slides.[42]

North Carolina has developed one of the leading virtual education systems in the country. The North Carolina Virtual Public School offers rural middle school students the opportunity to take high school courses that would be otherwise unavailable. The option of pursuing high school courses has long been available to their suburban counterparts. NCVPS increases equity in access at a lower cost than a traditional course, and student outcomes are about equal between the virtual and traditional classroom environment in eighth grade. Virtual education has rapidly expanded in recent years, and it seems unlikely that the trend will reverse anytime soon. The topic requires more research, but the present results should bolster virtual education advocates' arguments and encourage cautious school and district policymakers to expand access to highly motivated students. With a focus on targeted growth and meeting student needs, NCVPS can offer North Carolina students an exceptional program that other states can emulate.

[41] Teachers have the option of creating video lectures, but most do not.

[42] NCVPS should incorporate additional technology as well. For instance, Frailch, Kesner, and Hofstein (2009) find that tenth grade chemistry students learned more about chemical bonding concepts when their classroom was supplemented with integrated visualization tools and active learning.

APPENDIX A: K-12 STUDIES INCLUDED IN THE DEPT. OF EDUCATION META-ANALYSIS

This section provides details on the studies of the five K-12 studies included in the 2010 U.S. Department of Education meta-analysis. Englert et al. (2007) found that a web-based tool improved the writing of elementary school students with disabilities, while Long and Jennings (2005) found that "electronic field trips" provided a small but statistically insignificant boost to eighth grade social studies students' understanding of the Underground Railroad. West Virginia middle school students in a blended introductory Spanish course performed about as well as their peers in a traditional classroom (Rockman et al., 2007). Sun, Lin, and Yu (2008) found that fifth grade Taiwanese science students using a web-based virtual science lab performed significantly better than their peers in a traditional classroom.

O'Dwyer, Carey, and Kleiman (2007) provide the study perhaps most applicable to the NCVPS Algebra I and English I courses. The authors examined the effectiveness of the Louisiana Algebra I online course for 231 eighth and ninth grade students. Students in this program met on a standard course schedule, and schools provided each student with an internet-connected computer. Students had two teachers: an experienced, certified mathematics teacher and an in-class teacher that supervised and facilitated in-class activities. The researchers found no statistical difference between students in the online program and students in traditional classrooms.

Several of the K-12 programs included in the Department of Education meta-analysis used a blended method, with the online component supplemented by classroom-based instruction. The courses bear limited resemblance to the rapidly expanding virtual schools that provide entirely online instruction to thousands of high school students each year. Perhaps the most surprising result of these studies is that the additional special instruction supplementing the classroom experience had limited benefits for the students.

APPENDIX B: NCVPS IMPLEMENTATION

Appendix B provides additional background on the specific implementation of virtual education in North Carolina. NCVPS uses a combination of asynchronous and synchronous tools.[43] No adult supervision is required, although to ensure parental involvement teachers must contact parents at least once a week. High-demand courses like Algebra I and English I have multiple teachers for the subject. Every weekday, at least one teacher hosts a live chat room tutoring session that any student in the course can attend. Teachers can provide feedback via email or voice messages, and normal school hours do not constrain communication. The out-of school contact potentially presents substantial benefits to NCVPS students. A local non-scientific online news poll found that 61% of parents (answered "No, no contact whatsoever" to the question "Do your children have contact with teachers outside of school?") (WRAL, 2011; N=843). The poll was not scientific or random, but the substantial majority does give evidence that traditional students have little contact with their teachers outside of the school day.

[43] Asynchronous tools include email, PowerPoint presentations, voice messages, videos, and other lesson plan materials. Synchronous tools include live chat room tutoring sessions, phone calls, instant messaging, and texting.

Notably, NCVPS does not limit itself to offering niche courses that would be otherwise unavailable to students (e.g. AP, language, and credit recovery courses). Students can also take required algebra, English, and history courses through the online platform. Thus, students do not necessarily take NCVPS courses because no other option exists; they can also select the online option over a traditional classroom setting.

Enrollments include homebound, home school, charter school, and traditional public school students. Importantly, teachers often do not know why their students are pursuing virtual education. Given the wide variety of motivations that could drive students to the virtual platform, teachers may have difficulties adjusting their instruction for the particular needs of their students.

NCVPS carefully vets it prospective teachers. Only teachers with a history of success in their face-to-face classrooms are allowed to participate in an intensive training program. For eighteen weeks, trainees work with an experienced NCVPS teacher to learn the virtual course delivery methodology, after which NCVPS gives virtual sections to only the most qualified teachers.

Table B1 displays the courses available for the 2011-12 school year.[44]

[44] Courses marked by an asterisk are taught by an outside provider.

TABLE B1: 2011-12 NCVPS COURSE OFFERINGS

Area	Title	Duration
Advanced Placement	AP Art History	Year-long
	AP Biology	Year-long
	AP Calculus AB	Year-long
	AP Calculus BC	Year-long
	AP Computer Science A	Year-long
	AP English Language and Composition	Year-long
	AP English Literature and Composition	Year-long
	AP Environmental Science	Year-long
	AP European History	Year-long
	AP German V*	Year long
	AP Government and Politics US	Year-long
	AP Human Geography	Year-long
	AP Latin Vergil	Year-long
	AP Mandarin V	Year-long
	AP Macro / Microeconomics*	Year-long
	AP Music Theory	Year-long
	AP Psychology	Year-long
	AP Statistics	Year-long
	AP US History	Year-long
	AP World History	Year-long
Arts	Art I Drawing and Design	Block
	Digital Photography	Block
	Music Appreciation	Block
	Video Editing	Block
Career and Technical Education	Accounting I	Block
	Computer Applications I	Block
	Computerized Accounting I	Block
	Computer Programming I	Block
	Digital Communications	Block
	Personal Finance	Block
	Principles of Business and Finance (BE/ME)	Block
	Small Business Entrepreneurship (BE/ME)	Block
Credit Recovery	Algebra I	Block
	Algebra II	Block
	Biology	Block
	Civics and Economics	Block
	English I	Block
	English II	Block
	English III	Block
	English IV	Block
	Geometry	Block
	Physical Science	Block
	US History	Block
	World History	Block

TABLE B1: 2011-12 NCVPS COURSE OFFERINGS (CONTINUED)

Elective	Success 101	Block
English	English I	Block
	English II	Block
	English III	Block
	English IV	Block
	Journalism	Block
Health Education	Health Education	9 Weeks
Honors	Algebra II Honors	Block and Year-long
	Anatomy and Physiology Honors	Block
	Biology Honors	Block
	Calculus Honors	Block
	Chemistry Honors	Block
	Civics and Economics Honors	Block
	Earth / Environmental Science Honors	Block
	e-Commerce 1 Honors	Block
	e-Commerce II Honors	Block
	English I Honors	Block
	English II Honors	Block
	English III Honors	Block
	English IV Honors	Block
	French III Honors	Block and Year-long
	French IV Honors	Block
	Geometry Honors	Block and Year-long
	German III Honors*	Block
	German IV Honors*	Block
	Latin III Honors	Block and Year-long
	Mandarin Chinese Language and Culture III	Block
	Mandarin Chinese Language and Culture IV	Block
	Pre-Calculus Honors	Block
	Psychology Honors	Block
	Spanish III Honors	Block and Year-long
	Spanish IV Honors	Block
	US History Honors	Block
	World History Honors	Block
Math	Advanced Functions and Modeling	Block
	Algebra I	Block and Year-long
	Algebra II	Block
	Geometry	Block and Year-long
	Integrated Math I	Block
	Integrated Math II	Block

TABLE B1: 2011-12 NCVPS COURSE OFFERINGS (CONTINUED)

Occupational Course of Study[45]	English I	Block
	English II	Block
	Algebra I	Block
	Biology	Block
Science	Biology	Block
	Earth / Environmental Science	Block and Year-long
	Physical Science	Block
Social Studies	African-American Studies	Block
	Civics and Economics	Block
	Leadership Development	Block
	Medieval Studies	Block
	Psychology	Block
	US History	Block
	World History	Block
Test Prep	SAT Prep	Block
World Languages	Arabic I	Block
	Arabic II	Block
	Russian I	Block
	Russian II	Block
	Japanese I	Block
	Japanese II	Block
	Latin I	Block and Year-long
	Latin II	Block and Year-long
	Mandarin Chinese Language and Culture I	Block
	Mandarin Chinese Language and Culture II	Block
	Spanish I	Block and Year-long
	Spanish II	Block and Year-long
	French I	Block and Year-long
	French II	Block and Year-long
	German I	Block and Year-long
	German II	Block and Year-long

APPENDIX C: DISTRIBUTION OF NCVPS STUDENTS IN POLICY CONTEXT

Policymakers intended for NCVPS to provide high-quality education to rural and low-wealth counties. In the analysis that follows, I examine the extent to which NCVPS meets these expectations with its Algebra I and English I courses. Notably, the General Assembly specified the unit as counties, which may differ somewhat from the students and their schools. Thus, if many wealthy students in a low-wealth county pursue NCVPS, the program may meet the letter if not the spirit of the initiative. I find that NCVPS successfully reaches rural counties in Algebra I but not English I. I find no difference by county wealth.

[45] OCS courses are blended and include both NCVPS teachers and face-to-face teachers.

A. NCVPS IN RURAL AREAS

Table C1 displays the distribution of NCVPS for rural and non-rural school districts.[46] It appears that 2.8% of rural Algebra I EOC-test takers used NCVPS, compared to less than 0.5% of non-rural students. In other words, students in rural districts are 464.2% more likely to use NCVPS than non-rural students. In English I, rural students are half as likely to use NCVPS; 1.5% of rural students used NCVPS, compared to 3.0% of non-rural students.

TABLE C1: RURAL DISTIBUTION OF STUDENTS

	Rural Districts	Non-Rural Districts
Algebra I	2.5%	0.6%***
English I	1.5%	3.0%***

*Statistically significant differences are indicated as follows: * p<0.05, ** p<0.01, *** p<0.001*
All t-tests assume unequal variance between groups

At the school (rather than district) classification level, 81.1% of Algebra I NCVPS students' schools are rural, compared to only 48.4% for traditional students. In English I, 33.3% of the NCVPS students are rural, compared to 49.3% for traditional students. Thus, it appears that NCVPS successfully targets its services to rural students in Algebra I but not English I.

B. NCVPS FOR LESS AFFLUENT STUDENTS

Next, I examine NCVPS success at targeting its services to low-wealth counties. I use each county's average household income as an indicator for county wealth in the following OLS regression:

EQUATION 4

$$\text{NCVPS}_c = \gamma + \pi_1 \text{Income}_c + \varepsilon_c ,$$

where NCVPS is the percent of virtual students in county c, γ is the constant, Income is the county's median household income, and ε is the error. Thus, the coefficient π will be negative and statistically significant if the less affluent counties have greater NCVPS participation than the more affluent counties. To account for potential non-linearity in the relationship between income and NCVPS participation, I also use the following equations:

EQUATION 5

$$\text{NCVPS}_c = \gamma + \pi_1 \text{Income}_c + \pi_2 \text{Income}_c^2 + \varepsilon_c ,$$

EQUATION 6

$$\text{NCVPS}_c = \gamma + \tau_c^Q + \varepsilon_c ,$$

[46] In North Carolina, school districts largely reflect county lines. Of the 115 school districts and 100 counties, county lines delimit the school district outer boundaries for 100 of the school districts, with the additional 15 districts serving specific cities within the counties.

where Equation 5 uses a squared term for county-level income and Equation 6 uses a series of indicator variables for each income quartile (Q=1,2,3,4). Table C2 displays the results of these regressions.

TABLE C2: REGRESSION RESULTS FOR NCVPS USE BY COUNTY INCOME

	Algebra I			English I		
	(1) % NCVPS Students	(2) % NCVPS Students	(3) % NCVPS Students	(1) % NCVPS Students	(2) % NCVPS Students	(3) % NCVPS Students
Median Household Income (1,000's of $s)	0.075	0.188		-0.013	-0.010	
	(0.077)	(0.262)		(0.047)	(0.319)	
Median Household Income Squared		-0.001			0.000	
		(.002)			(0.003)	
First Income Quartile			*omitted*			*omitted*
Second Income Quartile			0.304			0.194
			(0.404)			(1.285)
Third Income Quartile			-0.155			-0.182
			(0.169)			(1.215)
Fourth Income Quartile			1.529			-0.676
			(1.631)			(1.098)
Constant	-2.240	-4.607	0.316	2.478	2.399	2.113*
	(2.668)	(6.320)	(0.146)	(2.009)	(7.166)	(0.956)
Total N	100	100	100	100	100	100
R^2	0.017	0.017	0.025	0.001	0.001	0.007

Robust standard errors in parentheses
** p<0.05, ** p<0.01, *** p<0.001*

Overall, I found no statistically significant relationship between a county's median household income and NCVPS utilization. At the student level, FRL status provides an indicator of wealth for a given student. An analysis of percent FRL at the county level found similar results.[47]

About half of all students are on FRL. However, 29.4% of NCVPS Algebra I students and 64.5% of NCVPS English I students are on FRL. Thus, it appears that FRL students are *less* likely to pursue Algebra I on NCVPS than non-FRL students, while they are *more* likely to pursue English I virtually.

C. Summary of Results

Figure 4 in the main body of the paper displays the NCVPS enrollments by school location and student FRL status. Non-FRL rural students make up nearly 60% of all NCVPS Algebra I enrollments (and nearly 75% of NCVPS rural enrollments). For English I, students are more evenly distributed by location, but a large proportion of FRL students use NCVPS. Thus, the system does seem to reach rural students and less affluent students, but not necessarily both simultaneously.

[47] Results not shown.

APPENDIX D: SURVEY DETAILS

Part A of this section details the survey questions, while Part B provides additional response information.

A. SURVEY QUESTIONS

Teachers sent email links to students the Google survey in February 2012. All students began on the same page:

- Please select your grade *(radio buttons for grades 5-12 – only one check allowed)*
- Please select your sex *(drop-down selection for male/female – only one check allowed)*
- Please select the race/ethnicity to which you most identify *(drop-down selection for Non-Hispanic White, Hispanic, Black, Asian, Native American, and Other – only one check allowed)*
- How many courses are you taking through NCVPS *(radio buttons for One, Two, or Three or More – only one check allowed – answer directs students to next question)*

All students answered the following questions. If students indicated they were taking more than one course, they were instructed to answer the same set of questions for an additional course as well.

- Please select the course you are taking through NCVPS *(radio buttons for Algebra I, English I, and an "Other" category that students could fill in – only one check allowed)*
- What type of course is this? *(radio buttons for Regular, Advanced Placement (AP), Occupational Course of Study (OCS), and Credit Recovery (CR) – only one check allowed)*
- Some courses are more difficult than others. How would you rate the expected difficulty of the following courses:
    - This course, taken through NCVPS *(radio buttons for 1 (Least Difficult), 2, 3, or 4 (Most Difficult) – only one check allowed)*
    - This course, taken in a regular classroom (*radio buttons for 1 (Least Difficult), 2, 3, or 4 (Most Difficult) – only one check allowed)*
- What best describes your reason for taking this course online: *(checkboxes - only one check allowed)*

  __ I am taking this course for health reasons (broken bone, illness, pregnancy, etc.).

  __ This course is not offered at my school.

  __ I have taken and not passed this course in the past, and I am taking it online to stay on track for graduation.

  __ In order to take an overload of courses, I needed to take this course online.

  __ I prefer working on my own to working in a classroom.

__ My school thought it was the best option for me.

All students answered the following questions:

- Please describe why you're looking forward to taking a virtual course. *(open-ended question)*
- Please describe what worries you about taking a virtual course. *(open-ended question)*
- How did you learn about NCVPS? (*radio buttons for Friends, Parents, Teachers, Guidance Counselor/Other Administrations, and Other – only one check allowed)*
- Who most encouraged you to take this course through NCVPS? (*radio buttons for Friends, Parents, Teachers, Guidance Counselor/Other Administrations, and Other – only one check allowed)*
- Who most discouraged you to take this course through NCVPS? (*radio buttons for Friends, Parents, Teachers, Guidance Counselor/Other Administrations, and Other – only one check allowed)*
- Please describe how people encouraged you to try virtual schools. *(open-ended question)*
- What sort of support will you have as you take this course? *(checkboxes – students could select all that applied)*

  __ I have a computer at home.

  __ I have class time and computer access dedicated to this course during normal school hours.

  __ I have access to a school computer lab during school hours.

  __ I have access to a school computer lab after or before school hours.

  __ Other *(students could describe their other support if they chose to do so)*

- How worried are you about being able to complete your assignments and work? *(radio buttons for Not worried at all, Only a little worried, Somewhat worried, and Very worried – only one check allowed)*
- Please provide any final comments you would like to share about NCVPS *(open-ended question)*

B. ADDITIONAL SURVEY RESPONSE DETAILS

Parents and teachers encourage students to pursue virtual education in a variety of ways, and the table below details some specific student responses.[48]

[48] Students responded to the prompt: *"Please describe how people encouraged you to try virtual schools."* I made no changes to student responses. Students also responded to the questions *"Who most encouraged you to take a course through NCVPS?"* and *"Who most discouraged you to take a course through NCVPS?"* Guidance counselors/other administrators most frequently encouraged participation; 38.8% of students selected this response. Parents were the next most influential group at 17.3%. About 17.9% of students reported that their parents, teachers, or guidance counselors most discouraged them from pursuing NCVPS; 20.6% of students reported their friends were most discouraging. The remainder of students

TABLE D1: HOW PARENTS AND TEACHERS ENCOURAGED NCVPS REGISTRATION

mom and dad thought it would be a good way to get ahead for high school credits and my teachers said I would do well in online classes. (8th Grade Algebra I)	They said it would get me ahead and i could possibly graduate on time thats what most motivated me because i really want to graduate with my class (9th Grade Algebra I & English I)
We took this test last year at the end of 7th grade and if we passed it we got to take this high school class in 8th grade. So when I get to high school I will have a class I don't have to take and I will be ahead. (8th Grade Algebra I)	My school didn't get enough teachers to cover all the classes that had to be taught (9th Grade Algebra I)
I wasnt encouraged, I was forced. (8th Grade Algebra I)	I don't remember signing up for this class. I asked the other students who got this class also and they said they didn't sign up for it either. We were kinda of just given it. (10th Grade Algebra I)
My school would put me back in regular math. (8th Grade Algebra I Student)	
Well this is my first year at this school and i really want to take alegbra and this course was my only option but so far i like virtual schools. (8th Grade Algebra I)	nobody encouraged me cause i did not know i was goiong to have this class (10th Grade Algebra I and English I)
My guidance counselor said it was my only option to be able to get the credits for these two classes. (11th Grade Algebra I & Earth Sciences)	They said it was easy, and fast and I could learn quickly. (9th Grade Algebra I & English I)
the encourage me by saying it is fun and better than being in a class. (10th Grade Algebra I & English I)	I have to take these courses because it is a part of my punishment for being sent to the alternative program (9th Grade Algebra I & English I)
Nobody encouraged me, it was manitor for me to take the course online. (9th Grade Algebra I & English I)	My parents told me i could do anything if i just put my mind to it and they said i failed it with a teacher so leta try something diferent. (10th Grade Algebra I)

The next table displays a variety of specific concerns about NCVPS.[49] Middle school students worry about not having a teacher in front of them, with several students also mentioning technology crashes as a potential problem. High school students are more concerned about technology glitches, falling behind, and failing the course or the EOC test.

TABLE D2: STUDENT WORRIES ABOUT NCVPS

I have honestly not enjoyed this at all. I am a very visual person and this whole looking at words on a screen thing isnt working. I would way rather enjoy having a teacher in the classroom to help me hands on. We have a teacher who teaches the standard class while we are online, and she is supposed to help "guide and teach" us when needed but dang, she needs it more than us. I really like my online teacher (she rocks!!!) I just wish i would be able to learn from her in person. (8th Grade Algebra I)	I am worried about taking an online course because I am used to having a teacher in a class room with me. I am afraid I will not understand something and not have a teacher there to explain it to me. (8th Grade Algebra I)
I might not be able to complete assignments because of not owning a computer. (8th Grade Algebra I)	That I will forget to go on the computer and do my work on the computer. (9th Grade Algebra I)
	It worries me that I cannot have the voice and physical teacher, as well as being able to identify tone changes which can very well effect and change mood and the way things are conveyed. (11th Grade English I)

(61.5%) selected Other/Not Applicable for discouragement. This may imply two things: either that parents, teachers, and guidance counselors successfully kept students with a low propensity for success out of NCVPS, or that few people are discouraging students from pursuing the system.

[49] Students responded to the prompt: *"Please describe what, if anything, worries you about taking a virtual course."* I made no changes to student responses.

The only thing that worrys me about taking the class online is that i won't be able to get up with my teacher when I am out sick or if some thing goes wrong and I need to make up an assignment that has already closed out and I can't get back into it. Another thing that bothers me about the class online, is that I won't learn anything because I hove the appertunity to take eah homework and most of the tests over and over again until I get the grade that I am comfrontable with. Also, the notes that come with the lessons, are awful and they don't help you at all. You can learn anything from them and you can't really understand them either. (8th Grade Algebra I)	i dont wanna be doing my work and the computer crashes and i loose all my work becuase that has happend before. (9th Grade Algebra I & English I) If i do get worried it would be about falling behind if anything because sometimes i have my days when i dont feel like doing anything but i half to get over that. (9th Grade Algebra I & English I) I am having a very hard time understanding what I am reading even when I take notes & I seam to fall behind. (12th Grade Algebra I) That I may fail it because I only have school internet access.(9th Grade English I)

Despite potential concerns, many students indicated they looked forward to their courses for a variety of reasons; the following table displays a sampling of student comments.[50] They frequently reported that they like technology and working at their own pace; middle school students also looked forward to getting high school credit out of the way. Several high school students reported that their friends or others said NCVPS would be easier than the regular classroom. One student mentioned avoiding bullies, while others reported being distracted in traditional classrooms.

TABLE D3: WHAT STUDENTS ENJOY ABOUT NCVPS

I am looking forward to taking more virtual courses with NCVPS because I love anything dealing with computers, and I think virtual classes can help out schools by not having to find teachers just to teach for a certain class. (8th Grade Algebra I) I am looking forward to being able to work at my own pace. (8th Grade Algebra I) I like it because its really cool to be able to meet new people across north carolina, and its also a lot easier than just writing notes on paper, and then going home and doing it. (8th Grade Algebra I) I am looking forward to taking this class because I will have a creidt out of the way. I also won't have to take it when I get to highschool because I will have already hopefully passed the class and EOC online. (8th Grade Algebra I) I am looking forward to taking this course because algebra was not offered for my grade at my school so I was offered to take the course online, which I accepted. (8th Grade Algebra I)	I skipped 8th grade and this course allows me to catch up with the rest of my grade. (9th Grade Algebra I) Our school made us take a test and I passed so I took the class. (8th Grade Algebra I) it's easier than being in a classroom with a teacher (9th Grade Algebra I) So I can hopefully graduate early. (9th Grade Algebra I & English I) I like being able to see my actual grades right after I complete assignments, and I like being able to go back and correct my work. (8th Grade Algebra I) because I do not do well in normal classroom due to distractions (9th Grade Algebra I & English I) I will be able to concentrate and will not get bullied as I was at school. (9th Grade Algebra I & English I) I am looking forward to taking a virtual course because I am so ready to graduate. (12th Grade Algebra I)

[50] Students responded to the prompt: *"Please describe why you're looking forward to taking a virtual course."* I made no changes to student responses.

APPENDIX E: STUDENT WEIGHTING

Student weighting can be used to balance a comparison of students based on their characteristics. For instance, early-taking students score higher on the EOC because of their natural ability, and a larger proportion of NCVPS Algebra I students are early-takers compared to the traditional distribution. Thus, based on the distribution of student grades along, NCVPS appears to have better outcomes than the traditional classroom. Table E1 displays the average results for Algebra I and English I in both groups by grade. The boxed comparisons highlight the most common grades for pursuing NCVPS in Algebra I and English I (eighth and ninth grade, respectively).

TABLE E1: STANDARDIZED TEST SCORES BY GRADE AND COURSE TYPE

	Algebra I			*English I*		
	NCVPS Classroom (s.d.)	Traditional Classroom (s.d.)	Difference (δ) (t-statistic)	NCVPS Classroom (s.d.)	Traditional Classroom (s.d.)	Difference (δ) (t-statistic)
Grades 5-7	0.78	1.05	-0.31***	N/A	N/A	N/A
	(0.63)	(0.82)	(9.10)			
Grade 8	0.69	0.80	-0.11***	0.72	0.51	0.21*
	(0.76)	(0.81)	(5.07)	(0.71)	(0.86)	(-2.56)
Grade 9	-1.41	-0.13	-1.28***	-0.98	0.10	-1.08***
	(0.84)	(0.84)	(12.41)	(0.72)	(0.95)	(63.80)
Grade 10	-1.21	-0.64	-0.57***	-1.32	-1.24	-0.08*
	(0.70)	(0.78)	(5.61)	(0.83)	-0.88	(2.16)
Grades 11-12	-1.05	-0.78	-0.26	-1.26	-1.14	-0.12
	(0.89)	(0.73)	(1.83)	(0.96)	(0.86)	(0.90)
All Grades	0.56	0.03	0.53	-1.01	0.02	-1.03
	(0.91)	(0.97)	(-24.81)	(0.83)	(0.98)	(63.65)

*Statistically significant differences are indicated as follows: * p<0.05, ** p<0.01, *** p<0.001*
All t-tests assume unequal variance between groups
English I Grade 8 contains the small number of Grade 7 students who pursued the course.

In Algebra I, traditional students outperform their NCVPS counterparts at every grade level. Only the eleventh/twelfth grade gap is not statistically significant. Similar patterns occur in English I, though the few early takers actually out-perform their traditional counterparts. The differences are particularly stark in ninth grade (δ=-1.28 and -1.08 standard deviations for Algebra I and English I, respectively). However, the *overall* Algebra I difference is positive (δ=0.53 standard deviations) because the higher proportion of NCVPS students in the high-achieving grades pull up the average. To counteract the distributional differences, I calculate a weighted average as follows:

EQUATION 7

$$\sum_{g=1}^{5}(\text{Traditional}_g - \text{NCVPS}_g)p_g = \sum_{g=1}^{5}\delta_g p_g$$

where for each grade *g* (1=fifth, sixth, and seventh grade; 2=eighth grade,…,5=eleventh and twelfth grade), Traditional is the average standardized score for traditional students, NCVPS is the average standardized score for virtual students, δ is the difference between the averages, and *p* is the proportion of NCVPS students. Using this formula, on average NCVPS students underperformed relative to traditional students in the same grade by 0.21 standard deviations in Algebra I and 0.79 standard deviations in English I.[51]

A. Basic Weighting on Prior Performance Decile and FRL Status

In basic OLS regressions, the analysis examines the mean difference between the treatment group and the control group, holding other factors constant. However, this method may lead to an imbalanced comparison between the groups. For instance, the Algebra I NCVPS students are less likely to on free and reduced price lunch than the traditional students. Weighting allows a balanced comparison between groups. To accomplish the comparison, I break the data into 22 cells: the columns are defined by FRL status ($f = 1$ indicates on FRL; $f = 2$ indicates non-FRL), while the rows are defined by the decile j of performance on the most recent EOG-math test ($j = 1,2,\ldots,10$). An additional row ($j = 11$) includes students without prior test scores. The weight w_{jf} for past performance group j in location r is calculated as:

EQUATION 8

$$w_{jr} = \begin{cases} 1 & if\ NCVPS = 1 \\ \dfrac{p^{v}_{jf}}{p^{t}_{jf}} & if\ NCVPS = 0 \end{cases}$$

where p^{v}_{jf} is the fraction of virtual students in a given cell and p^{t}_{jf} is the fraction of traditional students in a given cell. See Table E2 for the cell distribution and weights for Algebra I. For instance, about 4% of NCVPS students are in decile 1 and on FRL, whereas 6% of traditional students are in decile 1 and on FRL. FRL students tend to perform worse on standardized tests than non-FRL students, so the relatively higher proportion of FRL students would likely bring the average traditional score lower. Using the weight of 0.64 (as opposed to 1.00) in the final column balances the distribution.

All traditional students on FRL, non-FRL traditional students in deciles 7 and 10, and traditional students missing EOG-math scores are down-weighted, while traditional non-FRL students in deciles 1-6 and 8-9 are up-weighted. This approach balances the effect of FRL status and prior performance decile on score outcomes, and the effect of these factors will be zeroed out between NCVPS and traditional students.

[51] In statistics parlance, the weighted average is the estimated effect of the treatment on the treated.

TABLE E2: EXAMPLE ALGEBRA I WEIGHTING

	NCVPS Students		Traditional Students		Weight for Traditional Students (wjr)	
	Non-FRL	FRL	Non-FRL	FRL	Non-FRL	FRL
Decile 1	7%	4%	6%	6%	1.28	0.70
Decile 2	8%	4%	7%	4%	1.28	0.96
Decile 3	10%	3%	7%	4%	1.50	0.82
Decile 4	4%	1%	4%	2%	1.05	0.59
Decile 5	9%	2%	8%	3%	1.12	0.80
Decile 6	11%	2%	9%	4%	1.14	0.70
Decile 7	6%	1%	4%	1%	1.41	0.91
Decile 8	9%	1%	10%	3%	0.92	0.52
Decile 9	7%	1%	7%	1%	1.11	0.69
Decile 10	6%	0%	8%	1%	0.74	0.43
No EOG Data	1%	0%	2%	0%	0.41	0.00
Total	79%	21%	71%	29%	1.11	0.73

Using these weights, I can calculate the weighted effect of the treatment on the treated (for the NCVPS students) as follows:

EQUATION 9

$$\delta = \sum_{j=1}^{11} \sum_{r=1}^{2} \left(f_{jf}^{v} * \delta_{jf}\right) =$$

$$\sum_{j=1}^{11} \sum_{r=1}^{2} \left(f_{jr}^{v}\right) * [E(score|educ = j, FRL = f, v = 1) - E(score)|educ = j, rural = f, v = 0)]$$

where the estimated effect of NCVPS is the sum of the difference between NCVPS students ($v = 1$) and traditional students ($v = 0$) in each of the 22 ($j * f$)cells.

B. Propensity Score Matching Methodology

Using more than two control variables for the weighting methodology creates a multidimensional table of cells. To simplify the analysis, I can use available characteristics to estimate the probability that a student pursues the treatment; once this is established I can compare students with similar propensity to be in an NCVPS classroom who did and did not actually use NCVPS for Algebra I. The logic of the method is similar to the weighting assignment above.

In nearest neighbor matching, a statistical software package (in this case, Stata) selects the nearest controls to compare to each NCVPS observation. I specify that Stata selects five cases for each control; the particular choice depends on a tradeoff between consistency and power. In radius matching, Stata averages the outcomes for the controls within a particular propensity score range for each NCVPS observation. I use a 0.01 range in order to ensure that the treated cases are compared

only to the most likely controls. Overall, radius matching offers my preferred estimate, but I include the radius matching for the sake of comparability.

APPENDIX F: ADDITIONAL TABLES

TABLE F1: DESCRIPTIVE STATISTICS (FULL SAMPLE)

	Algebra I	English I
EOC Test Performance		
Score	154.0	152.3
Percent Passed	77.8%	81.0%
Student Past Performance		
EOG-Math (Z-Score)	0.06	0.01
EOG-Reading (Z-Score)	0.06	0.01
Missing EOG-Math	5.6%	7.4%
Missing EOG-Reading	5.8%	7.4%
Student Characteristics		
Percent NCVPS Students	1.5%	2.3%
Grade	8.9	9.0
Percent Female	48.9%	48.5%
Percent Non-white	46.9%	46.4%
Percent AIG (Math)	14.2%	13.2%
Percent AIG (Reading)	13.4%	12.7%
Percent EC	10.7%	13.6%
Percent FRL	48.6%	46.9%
Percent LEP	5.2%	5.4%
School Characteristics		
Percent in Charter Schools	1.3%	1.9%
Percent Rural	48.9%	49.0%
Percent Town	12.8%	13.2%
Percent Suburban	12.2%	12.9%
Percent Urban	26.2%	25.0%
Average Percent FRL in School	46.9%	
Average Percent Non-white in School	44.7%	
Total N	122,419	115,206

TABLE F2: DESCRIPTIVE STATISTICS FOR NCVPS AND TRADITIONAL STUDENTS (FULL SAMPLE)

	Algebra I		English I	
	NCVPS Classroom	Traditional Classroom	NCVPS Classroom	Traditional Classroom
EOC Test Performance				
Score	159.1***	154.0	143.3***	152.5
Percent Passed	92.3%***	77.6%	40.3%***	81.9%
Student Past Performance				
EOG-Math (Z-Score)	0.76***	0.05	-0.89***	0.03
EOG-Reading (Z-Score)	0.70***	0.05	-0.89***	0.03
Missing EOG-Math	1.7%***	5.7%	15.4%***	7.2%
Missing EOG-Reading	1.8%***	5.9%	15.4%***	7.2%
Student Characteristics				
Grade	7.9***	8.9	9.2***	9.0
Percent Female	49.1%	48.9%	40.5%***	48.7%
Percent Non-white	30.7%***	47.2%	72.9%***	45.7%
Percent AIG (Math)	39.9%***	13.8%	1.6%***	13.4%
Percent AIG (Reading)	36.3%***	13.0%	1.8%***	13.0%
Percent EC	5.9%***	10.8%	41.7%***	12.9%
Percent FRL	29.4%***	48.9%	64.5%***	46.5%
Percent LEP	1.6%***	5.3%	11.3%***	5.2%
School Characteristics				
Percent in Charter Schools	1.2%	1.3%	0.4%***	1.9%
Percent Rural	81.1%***	48.4%	33.3%***	49.3%
Percent Town	11.7%	12.8%	11.6%**	13.2%
Percent Suburban	0.7%***	12.4%	14.6%*	12.8%
Percent Urban	6.4%***	26.5%	40.5%***	24.6%
Average Percent FRL in School	43.3%***	46.8%		
Average Percent Non-white in School	40.1%	44.8%		
Total N	1,867	120,552	2,608	112,598

*Statistically significant differences are indicated as follows: * p<0.05, ** p<0.01, *** p<0.001*

All t-tests assume unequal variance between groups

TABLE F3: DESCRIPTIVE STATISTICS FOR NCVPS AND TRADITIONAL STUDENTS (LIMITED POPULATION)

	Very Early Takers			*8th Grade*		
	NCVPS Classroom	Traditional Classroom	Difference (δ)	NCVPS Classroom	Traditional Classroom	Difference (δ)
Algebra I EOC Test Performance						
Z-Score	0.86	1.12	-0.26***	0.75	0.79	-0.05
Percent Passed	99.6%	98.9%	0.8%	98.5%	97.1%	1.4%***
Student Past Performance						
EOG-Math (Z-Score)	1.32	1.39	-0.06	0.77	0.88	-0.11***
Missing EOG-Math	0.4%	3.5%	-3.12%***	0.9%	2.2%	-1.3%***
Student Characteristics						
Grade	7.00	6.97	0.02***	8.00	8.00	0.00
Percent Female	48.9%	46.2%	2.7%	47.9%	52.4%	-4.5%**
Percent Non-white	14.7%	36.4%	-21.6%***	26.0%	32.7%	-6.7%***
Percent AIG (Math)	69.8%	75.3%	-5.5%	35.4%	41.5%	-6.1%***
Percent AIG (Reading)	62.6%	64.3%	-1.7%	32.4%	36.7%	-4.3%**
Percent EC	2.5%	2.5%	0.1%	3.8%	2.4%	1.4%*
Percent FRL	10.4%	20.8%	-10.3%***	24.3%	29.6%	-5.3%***
Percent LEP	0.0%	0.9%	-0.9%***	1.2%	1.4%	-0.2%
School Characteristics						
Percent in Charter Schools	0.0%	0.8%	-0.8%***	2.3%	0.9%	1.4%**
Percent Rural	91.0%	33.2%	57.8%***	88.8%	44.2%	44.6%***
Percent Town	9.0%	6.6%	2.4%	11.2%	10.6%	0.6%
Percent Suburban	0.0%	6.5%	-6.5%***	0.0%	16.6%	-16.6%***
Percent Urban	0.0%	53.8%	-53.8%***	0.0%	28.6%	-28.6%***
Average Percent FRL in School	27.3%	43.8%	-16.5%***	34.7%	46.2%	-11.5%***
Average Perc. Non-white in School	30.4%	52.5%	-22.1%***	36.8%	43.1%	-6.3%***
Total N	278	2,760		867	24,379	

*Statistically significant differences are indicated as follows: * p<0.05, ** p<0.01, *** p<0.001*

All t-tests assume unequal variance between groups

TABLE F4: OLS REGRESSION RESULTS

	General Analysis					*Urbanizing Analysis*	
	(1) Z-Score	(2) Z-Score	(3) Z-Score	(4) Z-Score	(5) Z-Score	(6) Z-Score	(7) Z-Score
NCVPS	-0.053	-0.010	0.003	-0.033	0.036	-0.008	-0.042
	(0.075)	(0.030)	(0.027)	(0.031)	(0.027)	(0.038)	(0.051)
Grades 5-7			-0.164***	-0.160***	-0.137***	-0.134***	0.146
			(0.034)	(0.033)	(0.032)	(0.032)	(0.078)
NCVPS*Grades 5-7					-0.297***	-0.310***	-0.561***
					(0.088)	(0.088)	(0.118)
EOG-Math Decile 2		0.423***	0.392***	0.391***	0.391***	0.391***	0.215***
		(0.049)	(0.044)	(0.047)	(0.047)	(0.047)	(0.043)
EOG-Math Decile 3		0.683***	0.626***	0.624***	0.624***	0.623***	0.479***
		(0.050)	(0.044)	(0.048)	(0.048)	(0.048)	(0.047)
EOG-Math Decile 4		0.790***	0.737***	0.734***	0.736***	0.735***	0.573***
		(0.050)	(0.045)	(0.048)	(0.048)	(0.048)	(0.070)
EOG-Math Decile 5		0.962***	0.874***	0.867***	0.868***	0.868***	0.674***
		(0.051)	(0.045)	(0.049)	(0.049)	(0.049)	(0.054)
EOG-Math Decile 6		1.154***	1.047***	1.037***	1.039***	1.038***	0.871***
		(0.052)	(0.046)	(0.050)	(0.050)	(0.050)	(0.063)
EOG-Math Decile 7		1.315***	1.204***	1.190***	1.194***	1.193***	0.974***
		(0.052)	(0.046)	(0.051)	(0.051)	(0.051)	(0.081)
EOG-Math Decile 8		1.480***	1.333***	1.316***	1.317***	1.316***	1.048***
		(0.053)	(0.047)	(0.052)	(0.051)	(0.051)	(0.072)
EOG-Math Decile 9		1.699***	1.562***	1.539***	1.539***	1.539***	1.229***
		(0.055)	(0.050)	(0.056)	(0.056)	(0.056)	(0.056)
EOG-Math Decile 10		1.979***	1.810***	1.782***	1.780***	1.780***	1.430***
		(0.055)	(0.050)	(0.057)	(0.057)	(0.057)	(0.070)
EOG-Math Missing		0.961***	0.928***	0.896***	0.894***	0.893***	0.773***
		(0.063)	(0.056)	(0.059)	(0.059)	(0.059)	(0.109)
FRL			-0.159***	-0.121***	-0.121***	-0.121***	-0.0661*
			(0.016)	(0.018)	(0.018)	(0.018)	(0.028)
Non-white			0.004	0.015	0.014	0.016	0.013
			(0.014)	(0.014)	(0.014)	(0.014)	(0.031)
Female			0.0516***	0.0502***	0.0508***	0.0506***	0.0829**
			(0.008)	(0.008)	(0.008)	(0.008)	(0.026)
AIG (Math)			0.122***	0.116***	0.116***	0.114***	0.192***
			(0.015)	(0.015)	(0.015)	(0.015)	(0.051)
AIG (Reading)			0.0951***	0.0981***	0.0982***	0.0984***	0.117*
			(0.012)	(0.012)	(0.012)	(0.012)	(0.044)
EC			-0.122***	-0.138***	-0.140***	-0.140***	(0.108)
			(0.027)	(0.026)	(0.026)	(0.026)	(0.061)
LEP			0.043	0.045	0.045	0.045	0.309*
			(0.040)	(0.040)	(0.040)	(0.040)	(0.133)
Charter School				0.008	0.004	0.009	*no data*
				(0.056)	(0.057)	(0.057)	
Average Percent FRL in School				-0.310***	-0.313***	-0.310***	(0.266)
				(0.077)	(0.077)	(0.077)	(0.164)
Missing Percent FRL				0.143	0.143	0.125	-0.114
				(0.087)	(0.087)	(0.098)	(0.098)
Urbanizing						0.058	
						(0.041)	
Constant	0.828***	-0.187***	-0.155***	-0.017	-0.019	-0.021	0.174
	(0.029)	(0.052)	(0.043)	(0.073)	(0.073)	(0.073)	(0.089)
Clustered SE?	YES	YES	YES	YES	YES	YES	YES
Robust SE?	YES	YES	YES	YES	YES	YES	YES
Restricted to Urbanizing?	NO	NO	NO	NO	NO	NO	YES
Matching Estimator?	NO	NO	NO	NO	NO	NO	NO
N	28,284	28,284	28,284	28,284	28,284	28,284	1,986
R^2	0.0002	0.4961	0.5206	0.5252	0.5262	0.5263	0.4677

Standard errors in parentheses

** p<0.05, **p<0.01, *** p<0.001*

TABLE F5: LOGIT REGRESSION RESULTS FOR PASSING RATES

	General Analysis					*Urbanizing Analysis*	
	(1) Passing Rates	(2) Passing Rates	(3) Passing Rates	(4) Passing Rates	(5) Passing Rates	(6) Passing Rates	(7) Passing Rates
NCVPS	0.817	0.594	0.587	0.640	0.670	0.080	-2.299
	(0.617)	(0.416)	(0.362)	(0.396)	(0.432)	(0.235)	(2.035)
Grades 5-7			-0.482	-0.516	-0.501	-0.485	11.200
			(0.336)	(0.355)	(0.363)	(0.363)	.
NCVPS*Grades 5-7					-0.496	-1.084	-13.19***
					(1.216)	(1.235)	(1.662)
Previous EOG Z-Score		3.355***	3.179***	3.175***	3.176***	3.171***	3.630***
		(0.183)	(0.180)	(0.172)	(0.172)	(0.171)	(0.960)
Previous EOG Z-Score Squared		-0.515*	-0.415	-0.394	-0.391	-0.387	*no data*
		(0.212)	(0.226)	(0.246)	(0.247)	(0.246)	
FRL			-0.562***	-0.588***	-0.588***	-0.594***	1.135
			-0.107	-0.126	-0.126	-0.125	-0.908
Non-white			-0.166	-0.185	-0.185	-0.163	-1.325
			(0.112)	(0.110)	(0.110)	(0.109)	(0.828)
Female			0.417***	0.413***	0.413***	0.405***	1.794**
			(0.095)	(0.095)	(0.095)	(0.094)	(0.624)
AIG (Math)			0.153	0.160	0.159	0.144	*no data*
			(0.147)	(0.149)	(0.149)	(0.149)	
AIG (Reading)			0.550***	0.557***	0.558***	0.561***	*no data*
			(0.164)	(0.164)	(0.164)	(0.164)	
EC			-0.562**	-0.552**	-0.552**	-0.554**	-0.811
			(0.195)	(0.205)	(0.205)	(0.206)	(1.052)
LEP			0.073	0.074	0.074	0.071	*no data*
			(0.256)	(0.252)	(0.252)	(0.252)	
Charter School				0.767*	0.766*	0.795*	*no data*
				(0.306)	(0.305)	(0.311)	
Average Percent FRL in School				0.403	0.399	0.437	-7.677*
				(0.544)	(0.545)	(0.543)	(3.672)
Missing Percent FRL				0.961***	0.961***	0.561	-1.641
				(0.146)	(0.146)	(0.392)	(1.649)
Urbanizing						1.280**	
						(0.445)	
Constant	3.574***	3.007***	3.027***	2.803***	2.802***	2.760***	8.372**
	(0.198)	(0.209)	(0.226)	(0.285)	(0.285)	(0.286)	(3.077)
Clustered SE?	YES	YES	YES	YES	YES	YES	YES
Robust SE?	YES	YES	YES	YES	YES	YES	YES
Restricted to Urbanizing?	NO	NO	NO	NO	NO	NO	YES
Matching Estimator?	NO	NO	NO	NO	NO	NO	NO
N	28,284	28,284	28,284	28,284	28,284	28,284	1,986
Pseudo-R^2	0.0017	0.3625	0.3794	0.3810	0.3810	0.3829	0.3415

Standard errors in parentheses

** p<0.05, **p<0.01, *** p<0.001*

TABLE F6: PROPENSITY SCORE ANALYSIS FOR VERY EARLY TAKERS

	(1) Propensity	(2) Propensity	(3) Propensity	(4) Propensity
EOG-Math Decile 2	0.658	0.722	0.513	0.509
	(1.166)	(1.157)	(1.131)	(1.133)
EOG-Math Decile 3	2.048	2.001	1.749	1.744
	(1.050)	(1.044)	(1.040)	(1.042)
EOG-Math Decile 4	1.986	1.861	1.609	1.603
	(1.031)	(1.023)	(1.016)	(1.016)
EOG-Math Decile 5	2.529*	2.341*	1.881	1.877
	(1.034)	(1.028)	(1.024)	(1.025)
EOG-Math Decile 6	2.408*	2.200*	1.573	1.565
	(1.020)	(1.015)	(1.006)	(1.008)
EOG-Math Decile 7	2.423*	2.187*	1.248	1.235
	(1.019)	(1.015)	(1.010)	(1.011)
EOG-Math Decile 8	2.066*	1.815	0.534	0.524
	(1.026)	(1.024)	(1.025)	(1.025)
EOG-Math Decile 9	1.730	1.442	-0.026	-0.035
	(1.018)	(1.014)	(1.015)	(1.016)
EOG-Math Decile 10	1.215	0.942	-0.976	-0.989
	(1.024)	(1.020)	(1.035)	(1.035)
EOG-Math Missing	-0.390	-0.786	-2.606	-2.604
	(1.424)	(1.429)	(1.451)	(1.455)
FRL		-0.692**	-0.044	
		(0.226)	(0.254)	
Non-white		-1.005***	-0.479*	-0.476*
		(0.187)	(0.196)	(0.193)
Female		0.069	0.019	
		(0.131)	(0.146)	
AIG (Math)		-0.335*	-0.055	-0.108
		(0.169)	(0.203)	(0.174)
AIG (Reading)		0.000	-0.081	
		(0.155)	(0.180)	
EC		-0.271	-0.119	
		(0.401)	(0.416)	
Average Percent FRL in School			-6.732***	-6.744***
			(0.582)	(0.566)
Average Percent Nonwhite in School			-4.154***	-4.150***
			(0.378)	(0.376)
Constant	-4.174***	-3.379***	1.249	1.247
	(1.008)	(1.008)	(1.021)	(1.021)
Clustered SE?	YES	YES	YES	YES
Robust SE?	YES	YES	YES	YES
N	3,038	3,038	3,038	3,038
AIC	1,809.02	1,748.52	1,381.06	1,373.33
Pseudo-R^2	0.0389	0.0779	0.2777	0.2775

Standard errors in parentheses

** p<0.05, **p<0.01, *** p<0.001*

TABLE F7: PROPENSITY SCORE ANALYSIS FOR EIGHTH GRADE STUDENTS

	General Analysis				*Urbanizing*
	(1)	(2)	(3)	(4)	(5)
	Propensity	Propensity	Propensity	Propensity	Propensity
EOG-Math Decile 2	0.144	0.099	0.099	0.098	0.152
	(0.125)	(0.127)	(0.129)	(0.129)	(0.152)
EOG-Math Decile 3	0.176	0.105	0.085	0.084	-0.032
	(0.126)	(0.129)	(0.133)	(0.132)	(0.153)
EOG-Math Decile 4	-0.450*	-0.524**	-0.591**	-0.591**	-0.742***
	(0.184)	(0.187)	(0.190)	(0.189)	(0.207)
EOG-Math Decile 5	-0.132	-0.217	-0.296*	-0.297*	-0.542**
	(0.135)	(0.140)	(0.143)	(0.143)	(0.157)
EOG-Math Decile 6	-0.266*	-0.344*	-0.479***	-0.480***	-0.900***
	(0.134)	(0.141)	(0.144)	(0.143)	(0.162)
EOG-Math Decile 7	-0.482*	-0.578**	-0.779***	-0.779***	-1.264***
	(0.201)	(0.206)	(0.209)	(0.208)	(0.232)
EOG-Math Decile 8	-0.400**	-0.491***	-0.710***	-0.711***	-1.222***
	(0.140)	(0.148)	(0.152)	(0.151)	(0.174)
EOG-Math Decile 9	-0.485**	-0.570**	-0.853***	-0.852***	-1.383***
	(0.184)	(0.195)	(0.199)	(0.198)	(0.229)
EOG-Math Decile 10	-0.651***	-0.744***	-1.062***	-1.061***	-1.849***
	(0.184)	(0.197)	(0.203)	(0.200)	(0.232)
EOG-Math Missing	-1.046**	-1.176**	-1.590***	-1.597***	-2.552***
	(0.368)	(0.369)	(0.380)	(0.379)	(0.429)
FRL		-0.270**	0.159	0.158	0.068
		(0.089)	(0.093)	(0.092)	(0.108)
Non-white		-0.338***	-0.239**	-0.242**	0.307**
		(0.088)	(0.088)	(0.087)	(0.104)
Female		-0.173*	-0.184**	-0.185**	-0.218**
		(0.070)	(0.071)	(0.071)	(0.081)
AIG (Math)		-0.125	-0.200*	-0.184*	-0.690***
		(0.082)	(0.086)	(0.081)	(0.099)
AIG (Reading)		-0.022	0.030		
		(0.081)	(0.083)		
EC		0.315	0.082		
		(0.185)	(0.188)		
LEP		-0.020	-0.024		
		(0.329)	(0.342)		
Charter School			1.063***	1.060***	3.246***
			(0.244)	(0.243)	(0.303)
Average Percent FRL in School			-4.408***	-4.413***	-2.898***
			(0.197)	(0.197)	(0.216)
Urbanizing					6.270***
					(0.175)
Rural					2.834***
					(0.187)
Constant	-3.159***	-2.787***	-1.047***	-1.037***	4.980***
	(0.091)	(0.112)	(0.136)	(0.133)	(0.208)
Clustered SE?	YES	YES	YES	YES	YES
Robust SE?	YES	YES	YES	YES	YES
N	25,246	25,246	25,246	25,246	25,246
AIC	7,506.31	7,467.12	7,063.89	7,058.17	3,827.50
Pseudo-R^2	0.0087	0.0157	0.0697	0.0696	0.4983

Standard errors in parentheses

** p<0.05, **p<0.01, *** p<0.001*

TABLE F8: REGRESSION RESULTS FOR DOUBLY ROBUST WEIGHTED METHODOLOGY

	Very Early Takers				*Eighth Grade Students*			
	(1) Z-Score	(2) Z-Score	(3) Z-Score	(4) Z-Score	(5) Z-Score	(6) Z-Score	(7) Z-Score	(8) Z-Score
NCVPS	-0.292*	-0.258**	-0.256**	-0.254**	0.030	0.032	0.031	0.034
	(0.126)	(0.096)	(0.093)	(0.090)	(0.098)	(0.040)	(0.032)	(0.026)
EOG-Math Decile 2		0.341*	0.311**	0.306**		0.402***	0.376***	0.373***
		(0.138)	(0.095)	(0.102)		(0.061)	(0.052)	(0.052)
EOG-Math Decile 3		0.514**	0.422**	0.449**		0.679***	0.609***	0.602***
		(0.175)	(0.155)	(0.148)		(0.067)	(0.054)	(0.053)
EOG-Math Decile 4		0.636***	0.499***	0.531***		0.828***	0.729***	0.719***
		(0.093)	(0.097)	(0.091)		(0.083)	(0.070)	(0.068)
EOG-Math Decile 5		0.734***	0.615***	0.635***		0.958***	0.849***	0.835***
		(0.133)	(0.125)	(0.116)		(0.067)	(0.054)	(0.052)
EOG-Math Decile 6		0.900***	0.756***	0.774***		1.173***	1.030***	1.011***
		(0.139)	(0.136)	(0.126)		(0.071)	(0.056)	(0.056)
EOG-Math Decile 7		1.105***	0.915***	0.917***		1.324***	1.160***	1.136***
		(0.141)	(0.129)	(0.115)		(0.079)	(0.076)	(0.077)
EOG-Math Decile 8		1.226***	1.023***	0.997***		1.552***	1.336***	1.314***
		(0.197)	(0.172)	(0.152)		(0.072)	(0.049)	(0.048)
EOG-Math Decile 9		1.498***	1.280***	1.249***		1.675***	1.465***	1.435***
		(0.154)	(0.135)	(0.115)		(0.067)	(0.056)	(0.054)
EOG-Math Decile 10		1.728***	1.498***	1.454***		1.988***	1.730***	1.709***
		(0.127)	(0.106)	(0.088)		(0.071)	(0.059)	(0.061)
EOG-Math Missing		1.638***	1.392***	1.473***		1.015***	0.916***	0.898***
		(0.193)	(0.144)	(0.186)		(0.076)	(0.093)	(0.080)
FRL			-0.136	-0.086			-0.145***	-0.110***
			(0.078)	(0.070)			(0.026)	(0.025)
Non-white			0.103**	0.0884*			-0.0394*	-0.031
			(0.039)	(0.040)			(0.020)	(0.022)
Female			-0.007	-0.011			0.102***	0.0993***
			(0.044)	(0.043)			(0.017)	(0.018)
AIG (Math)			0.165**	0.155*			0.142***	0.141***
			(0.060)	(0.062)			(0.035)	(0.035)
AIG (Reading)			0.069	0.060			0.156***	0.154***
			(0.061)	(0.060)			(0.029)	(0.026)
EC			0.019	0.005			-0.071	-0.0909*
			(0.119)	(0.119)			(0.043)	(0.040)
LEP			0.471*	0.476**			0.108	0.121
			(0.208)	(0.175)			(0.061)	(0.064)
Charter School				-0.293				0.043
				(0.266)				(0.054)
Average Percent FRL in School				-0.647*				-0.441***
				(0.326)				(0.068)
Missing Percent FRL				0.391***				0.138
				-0.104				(0.082)
Constant	1.154***	-0.005	0.013	0.204	0.716***	-0.145*	-0.146**	0.008
	(0.103)	(0.151)	(0.128)	(0.145)	(0.043)	(0.063)	(0.056)	(0.069)
Clustered SE?	YES	YES	YES	YES	YES	YES	YES	YES
Robust SE?	YES	YES	YES	YES	YES	YES	YES	YES
Restricted to Urbanizing?	NO	NO	NO	NO	NO	NO	NO	NO
Matching Estimator?	YES	YES	YES	YES	YES	YES	YES	YES
N	3,038	3,038	3,038	3,038	25,246	25,246	25,246	25,246
R^2	0.0464	0.3492	0.3743	0.3834	0.0004	0.5033	0.5412	0.5472

Standard errors in parentheses

** p<0.05, **p<0.01, *** p<0.001*

TABLE F9: FULL SEVENTH GRADE PANEL DATA RESULTS

	Full Inclusion Model			*Restricted Model*		
	(1) Z-Score	(2) Z-Score	(3) Z-Score	(4) Z-Score	(5) Z-Score	(6) Z-Score
Est. Effect of NCVPS	-0.251**	-0.243**	-0.248**	-0.250**	-0.244**	-0.249**
	(0.089)	(0.089)	(0.088)	(0.090)	(0.090)	(0.088)
Clustered SE?	YES	YES	YES	YES	YES	YES
Robust SE?	YES	YES	YES	YES	YES	YES
Time and Student Fixed Effects?	YES	YES	YES	YES	YES	YES
EOG/EOC Grades Included	3-7	4-7	5-7	3-7	4-7	5-7
N (Total Entries)	14,840	11,872	8,904	14,615	11,732	8,826
N (Total Unique Students)	2,968	2,968	2,968	2,923	2,933	2,942
Percent of Restricted 7th Grade Population	100.0%	100.0%	100.0%	98.5%	98.8%	99.1%
R^2	0.2294	0.2542	0.2704	0.2268	0.2522	0.2686

Standard errors in parentheses

** p<0.05, **p<0.01, *** p<0.001*

The full inclusion specification includes all 7th grade students in the population; missing data points are estimated as the average for a given test in a given year

The restricted specification excludes students with missing data in any year.

TABLE F10: FULL EIGHTH GRADE PANEL DATA RESULTS

	Full Inclusion Model			*Restricted Model*		
	(1) Z-Score	(2) Z-Score	(3) Z-Score	(4) Z-Score	(5) Z-Score	(6) Z-Score
Est. Effect of NCVPS	0.052	0.062	0.083	0.053	0.063	0.083
	(0.062)	(0.064)	(0.070)	(0.063)	(0.065)	(0.070)
Clustered SE?	YES	YES	YES	YES	YES	YES
Robust SE?	YES	YES	YES	YES	YES	YES
Time and Student Fixed Effects?	YES	YES	YES	YES	YES	YES
EOG/EOC Grades Included	4-8	5-8	6-8	4-8	5-8	6-8
N (Total Entries)	126,230	100,984	75,738	123,925	99,484	74,973
N (Total Unique Students)	25,246	25,246	25,246	24,785	24,871	24,991
Percent of Restricted 8th Grade Population	100.0%	100.0%	100.0%	98.2%	98.5%	99.0%
R^2	0.3131	0.3271	0.3441	0.3103	0.3251	0.3429

Standard errors in parentheses

** p<0.05, **p<0.01, *** p<0.001*

The full inclusion specification includes all 8th grade students in the population; missing data points are estimated as the average for a given test in a given year

The restricted specification excludes students with missing data in any year.

APPENDIX G: CROSS-TEST CORRELATION FOR VARIOUS MATH TESTS

Past performance on EOG-meth tests strongly predicts future math performance. The correlation between scores is greatest in tests temporally near each other, as seen in the table below. For instance, the correlation between Grade 7 and Grade 8 Math EOG test scores is 0.723, while the correlation between Grade 3 and Grade 8 Math EOG test scores is 0.581. Similarly, the correlation between the Grade 8 EOG math test score and the Algebra I test score is 0.723, while the correlation between the Grade 7 EOG math test score and the Algebra I test score is 0.701. The correlation coefficient between students' most recent EOG test and Algebra I EOC test is 0.722; recall that the particular grade used for the most recent results differs by student.

TABLE G1: CROSS-TEST SCORE CORRELATION FOR VARIOUS MATH TESTS

	Grade 3 Math EOG	Grade 4 Math EOG	Grade 5 Math EOG	Grade 6 Math EOG	Grade 7 Math EOG	Grade 8 Math EOG	Algebra I EOC
Grade 3 Math EOG	1.000						
Grade 4 Math EOG	0.624	1.000					
Grade 5 Math EOG	0.617	0.624	1.000				
Grade 6 Math EOG	0.630	0.612	0.663	1.000			
Grade 7 Math EOG	0.626	0.603	0.655	0.741	1.000		
Grade 8 Math EOG	0.581	0.561	0.612	0.695	0.754	1.000	
Algebra I EOC	0.557	0.539	0.589	0.660	0.701	0.723	1.000

Similar patterns occur in the limited middle school population as seen in the following table. For instance, students' seventh grade math EOG and Algebra I EOC test have a correlation coefficient of 0.755 in the limited population. The correlation between students' most recent EOG test and Algebra I EOC test is 0.703; recall that the particular grade used for the most recent results differs by student.

TABLE G2: WITHIN-STUDENT TEST SCORE CORRELATION FOR VARIOUS MATH TESTS (LIMITED POPULATION)

	Grade 3 Math EOG	Grade 4 Math EOG	Grade 5 Math EOG	Grade 6 Math EOG	Grade 7 Math EOG	Grade 8 Math EOG	Algebra I EOC
Grade 3 Math EOG	1.000						
Grade 4 Math EOG	0.714	1.000					
Grade 5 Math EOG	0.661	0.744	1.000				
Grade 6 Math EOG	0.652	0.732	0.740	1.000			
Grade 7 Math EOG	0.616	0.698	0.707	0.763	1.000		
Grade 8 Math EOG	0.597	0.674	0.696	0.742	0.755	1.000	
Algebra I EOC	0.562	0.642	0.647	0.683	0.720	0.821	1.000

APPENDIX H: ADDITIONAL STATISTICAL ANALYSIS

I describe three additional statistical methods that I used to confirm my analysis below: (A) propensity score matching, (B) doubly robust propensity score matching, (C) logit analysis of student passing rates, and (D) panel data analysis. I use the limited middle school population for all four methods. The results largely support the findings in the main body of the paper. Both propensity score methods and the panel data method both find that eighth grade NCVPS students score about the same on their Algebra I EOC test as similar traditional students, but about a 0.25 standard deviation gap exists between very young NCVPS students and very young traditional students. The passing rates are about the same across groups, because among this positively selected population most students pass the course.

A. PROPENSITY SCORE MATCHING

1. ANALYTICAL FRAMEWORK

In basic OLS regression, the analysis examines the mean difference between the treatment group and the control group, holding other factors constant. This method may lead to an imbalanced comparison between the groups; Table E1 in **Appendix E** highlights this possibility. Although traditional students outperformed NCVPS students at every stratum, a naïve estimate

would assert that NCVPS students outperformed traditional students. Using OLS regression to compare the outcomes of individuals who pursued the treatment to individuals who did not pursue the treatment *and* had no propensity to do so only provides information on the associations between the variables and the outcome. This method may falsely find a causal treatment effect because of selection bias. Moreover, if the values of the control variables do not overlap substantially in the treatment and control groups, the regression estimate is based primarily on treated subjects in one region of the X vector and control subjects in another. In this case, as Lunceford and Davidian state, "estimates of causal effects using direct modeling are essentially based on extrapolation" (2004:2944).

Instead, I can use a matching technique to pair NCVPS treatment students with their most similar counterparts in the control population. The technique, referred to as propensity score matching, is designed specifically to isolate causal factors. The method has recently been used to examine the effects of a variety of potentially self-selected treatments, including Catholic school attendance on learning (Morgan, 2001), changes in family structure on academic outcomes (Frisco, Muller, and Frank, 2007), mission trips on youth spirituality (Trinitapoli and Vaisey, 2009), and whole-school reform on math and science pipelines (Miller and Corritore, 2011).

I again focus on middle school students whose schools only offer NCVPS or only offer the traditional classroom for Algebra I. As a first step, I examine several progressively more complicated logit models that estimate the probability that a particular student *i* will pursue NCVPS.[52] The most comprehensive of these models is as follows:

EQUATION 10

$$\Pr(v_i = 1) \mid X = F(a + \beta_1 PriorPerformance_i + \beta_2 Student_i + \beta_3 School_i + \varepsilon_i) = \frac{1}{1+e^{-(\alpha+\beta_1 PriorPerformance_i+\beta_2 Student_i+\beta_3 School_i+ \varepsilon_i)}},$$

where v_i is equal to 1 when student *i* used NCVPS for Algebra I. The other variables are as indicated in previous models.[53] In aggregate, the model predicts the probability that a student with a given set of characteristics would pursue NCVPS. I model the results separately for eighth grade students and very-early takers, as a preliminary analysis found substantially different results in the coefficients of the propensity estimate between the two groups.

I progressively add control variables in the same order as in the OLS regression series, and I use robust standard errors in the estimate.[54] Finally, I pare down the variables to exclude those that

[52] The variables used to predict NCVPS are those that are present prior to enrollment in Algebra I. Most recent EOG-math test scores, race, and sex are fixed pre-effects. I also include FRL, AIG, disability, and LEP status; an indicator for charter school; and the percentage of FRL students in a school. These features are not static per se, but they are stable and do predict the probability that a student pursues NCVPS.

[53] Note that no seventh grade students with disabilities or in charter schools pursued NCVPS, so the variables predict failure to pursue treatment perfectly. Thus, I exclude these variables from the analysis for the seventh grade population.

[54] I do not cluster standard errors at the school level. Due to the nature of the propensity score prediction, I expect many students from certain control schools to collectively have higher propensity to pursue NCVPS, and I do not want to ignore statistically significant differences because they trend within schools.

(1) have no statistically significant effect on propensity, (2) have no a priori theoretical reason for inclusion, and (3) do not add to the goodness of the fit of the model.[55] From this model, I predict a propensity score for each student in the grade of interest; this is the student's estimated probability of taking the Algebra I course through NCVPS. The present analysis focuses on the effects of NCVPS and not the causes; thus, I only briefly discuss the propensity score models.

Next, I use the propensity score matching command (psmatch2) developed by Leuven and Siansei (2003) to match students who used NCVPS for Algebra I with students with a similar propensity for NCVPS in the control group. In other words, I compare students who were very likely to pursue NCVPS *but who did not* with students who were very likely to pursue NCVPS *and who did*. Similarly, I compare students who were very unlikely to pursue NCVPS *and who did not* with students who were very unlikely to pursue NCVPS *but who did*. In other words, this is the propensity of a traditional student to use NCVPS if their school had offered it. I use these matches to compare the relative outcomes of NCVPS and traditional students on their standardized Algebra I EOC test score and their rate of passing. I use two separate but related matching estimates:[56]

- *Nearest Neighbor Matching*: Stata selects the nearest five controls to compare to each NCVPS observation.
- *Radius Matching*: Stata averages the outcomes for the controls within a 0.01 propensity score range for each NCVPS observation.

I estimate each matching methodology using bootstrapped standard errors separately for very early takers and eighth grade students.[57] Propensity score matching pairs similar cases; the model can therefore lose statistical power by dropping unmatched cases. The advantage is that the comparison then only occurs among observations that are truly alike.

2. BASIC RESULTS

Table F6 in **Appendix F** presents the outcomes from the propensity score analysis for the very early takers among the restricted Algebra I population. Column (1) indicates that the effect of previous test scores is nonlinear, with the greatest boost to propensity occurring in the middle deciles. The second model includes additional individual-level control variables. The results indicate that FRL, nonwhite, and AIG-math students are less likely to pursue NCVPS, holding other factors constant. When I add average percent FRL and percent nonwhite students in a school in the third specification, individual-level FRL loses its statistical significance.[58]

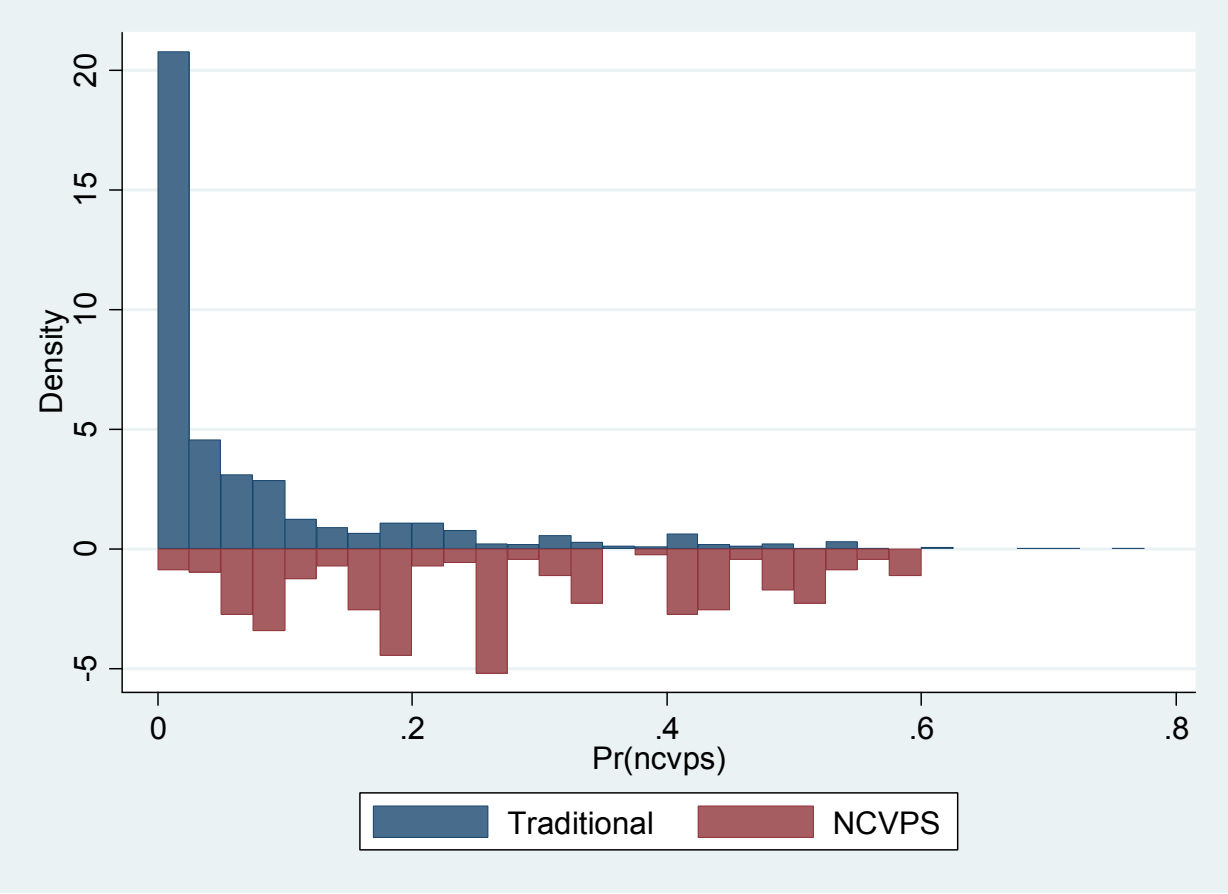
The final specification in column (4) eliminates the noise from several statistically insignificant variables, and the estimated coefficients are about the same between the two final

[55] A variable must meet all three criteria to be excluded. I evaluate significance at the 5% level. Past performance is the main variable I use regardless of significance. I use the BIC to evaluate whether a variable adds to the goodness of fit.
[56] I use replacement for both estimates.
[57] The bootstrapped estimates use 1,000 repetitions. No interaction estimate exists to compare the difference between eighth grade and younger students in the same matching estimate, so I estimate them separately.
[58] Note that individual-level FRL and macro-level FRL percentages are somewhat collinear; if a given student is on FRL, then his/her school likely has a higher percentage of FRL students.

models. I retain each decile of performance data because (1) a priori reasoning indicates that prior performance substantially affects the probability of pursuing NCVPS and (2) BIC model fit analysis indicates that deciles model the data more accurately than a linear or quadratic term. Interestingly, nonwhite students attending a school with more FRL and nonwhite students are substantially less likely to pursue NCVPS.

Figure H1 displays the bivariate distribution of propensity scores for very early takers who do and do not pursue the treatment. The traditional students' propensity scores range from zero to about 55%, with a few additional scores scattered at higher levels. The NCVPS students' scores range from 0 to about 60%.

FIGURE H1: VERY EARLY TAKERS' PROPENSITY FOR PURSUING NCVPS BY CLASSROOM TYPE



NCVPS students have limited support for comparison at the higher levels of the distribution, which has different effects with different matching techniques. For instance, using nearest neighbor matching means that the program matches NCVPS students at higher propensities to dissimilar students with lower propensity scores. At lower propensities, the NCVPS students have a wide selection of similar students to compare, and the program randomly selects among any ties for the nearest five. Using radius matching, the program compares NCVPS students to students within a 0.01 percentage point radius. This ensures that the comparison only occurs among like

students. At higher propensity levels, the program compares NCVPS students to few students; in some unsupported cases, they may not be compared to any students at all. At lower levels, each NCVPS students will be compared to the average of many traditional students whose propensity scores fall within the 0.01 percentage point range.

Table F7 in **Appendix F** presents the outcomes from the eighth grade propensity score logit analysis. As with the very early takers, Column (1) indicates that the effect of previous test scores is nonlinear; students in the higher deciles are less likely to pursue NCVPS. The second regression includes additional individual-level control variables. The model indicates that FRL, nonwhite, and female students are less likely to pursue NCVPS, holding other factors constant. When I add the average percent FRL students in a school and charter school status in the third specification, individual-level FRL loses its significance and the AIG-math coefficient becomes statistically significant.[59] The final specification in Column (4) eliminates the noise from several statistically insignificant variables. The estimated coefficients are about the same between the two final models, but I exclude the factors that have limited effect on the probability of pursuing NCVPS. I retain individual FRL status because (1) the coefficient is close to statistical significance (p-value=0.085) and (2) BIC model fit analysis indicates that including the variable improves model fit.

Figure H2 displays the bivariate distribution of propensity scores for students who do and do not pursue the treatment. The traditional students' propensity scores largely range from zero to about 15%, with a few additional students scattered from 15% to 30%. The NCVPS students' scores range from zero to 15%. Thus, some of the high-propensity traditional students may be excluded in the nearest neighbor and radius matching estimates.

[59] Note that individual-level FRL and macro-level FRL percentages are somewhat collinear; if a given student is on FRL, then his/her school likely has a higher percentage of FRL students.

FIGURE H2: EIGHTH GRADE STUDENTS' PROPENSITY FOR PURSUING NCVPS BY CLASSROOM TYPE

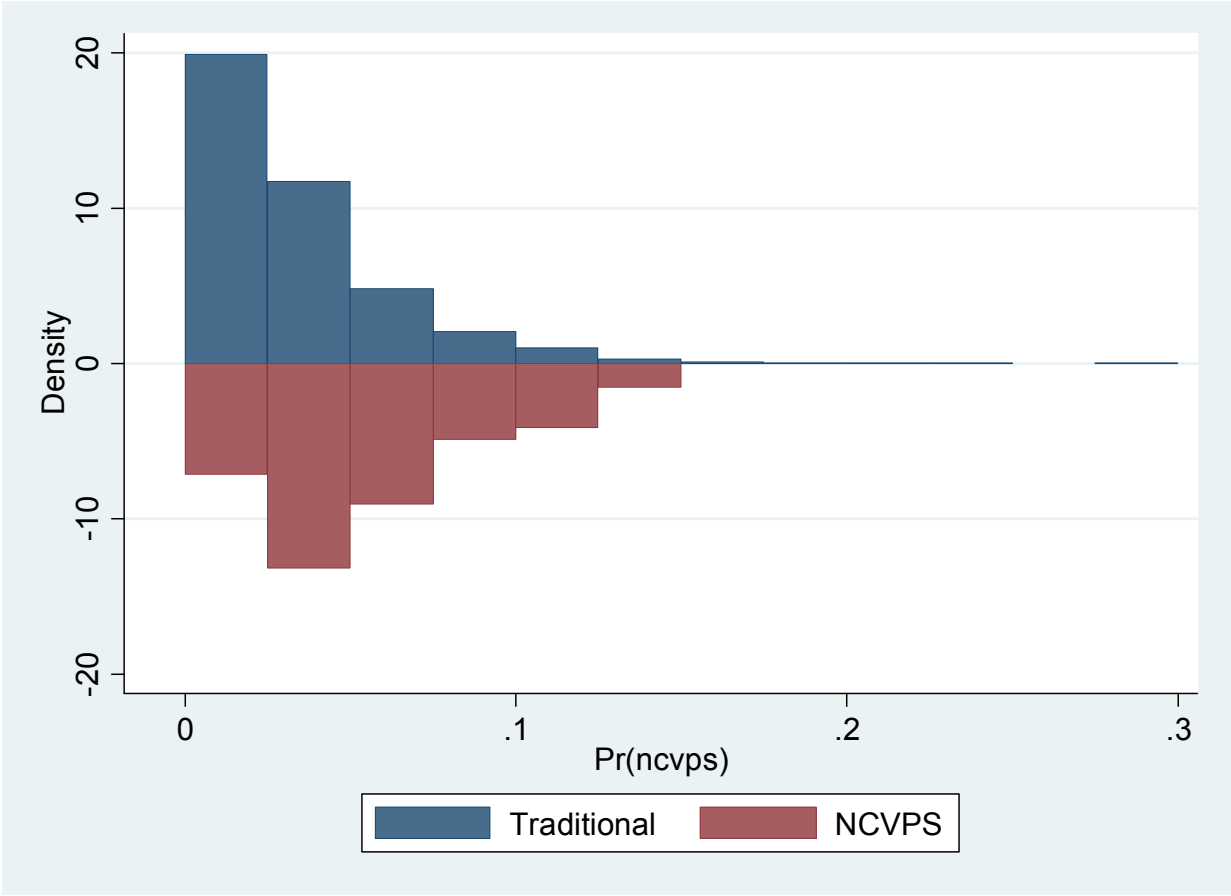


Table H1 reports the estimated difference in Z-scores for both age groups for the two matching methods.[60] Both methods estimate a large and statistically significant difference in scores between NCVPS and similar traditional students among the very early takers, ranging from -0.266 to -0.277 standard deviations. No statistically significant gap appears between similar NCVPS and traditional students in eighth grade. The results confirm the previous OLS analysis.

TABLE H1: Z-SCORE MATCHING RESULTS

	Very Early Takers	Eighth Grade Students
5 Nearest Neighbors	-0.266***	0.030
	(0.076)	(0.037)
0.01 Radius Matching	-0.277***	0.027
	(0.050)	(0.026)

Bootstrapped standard errors in parentheses (1000 repetitions)
** p<0.05, **p<0.01, *** p<0.001*

[60] A logit analysis of passing rates without matching can be found later in this appendix section. Due to the limited number of students who fail their EOC test among this positively selected population, the results are statistically insignificant by treatment, grade level, or an interaction thereof.

Table H2 reports the results for the passing rates of both age groups. The results indicate no statistically significant gap for the very early takers. Among eighth grade students, those that took the course through NCVPS have greater passing rates than traditional students when comparing students of similar treatment propensity. The results range from a 1.7 to a 2.3 percentage point increase. Though statistically significant, the differences are too small for policy relevance.

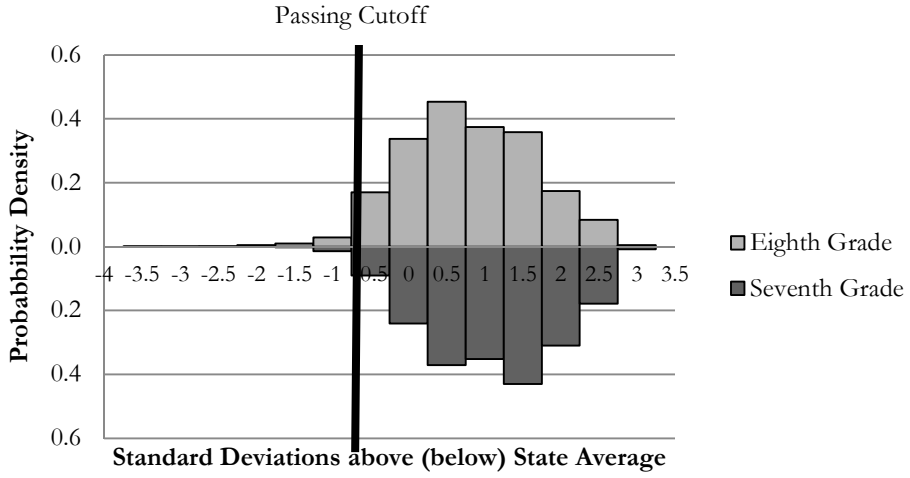
TABLE H2: PASSING RATES MATCHING RESULTS

	Very Early Takers	Eighth Grade Students
5 Nearest Neighbors	-0.216%	1.684%*
	(0.399)	(0.851)
0.01 Radius Matching	-0.206%	2.284%***
	(0.379)	0.452

Bootstrapped standard errors in parentheses (1000 repetitions)
** p<0.05, **p<0.01, *** p<0.001*

The passing results may seem counter to the score results presented above. Recall that most students score above the passing mark in this positively selected population.[61] Thus, although NCVPS sixth and seventh grade students score below their traditional peers, they still do not fall below the failing mark. Meanwhile, eighth grade students have a wider range of scores, which means that more students fall below the passing line. Figure H3 displays these distributions. Notably, very early takers actually have higher average EOC test scores, but the results show that *controlling for observable characteristics* NCVPS students perform worse than similar students in traditional classrooms.

FIGURE H3: HISTOGRAM OF SEVENTH AND EIGHTH GRADE ALGEBRA I EOC RESULTS



3. URBANIZING DISTRICT EFFECTS

As noted in the descriptive statistics overview, a large portion of NCVPS students attend school in one of the five urbanizing counties in North Carolina, and these counties systematically

[61] The passing mark was about 0.60 standard deviations below the average Algebra I EOC test result in 2010-11.

differ from other rural and non-rural counties. The previous propensity score matching analysis balanced the treatment and control groups on observable characteristics, but additional contextual factors may also affect students. Thus, I can add an indicator variable ($Urbanizing_i$) equal to one if student *i* attends a school in an urbanizing districts and zero otherwise, as follows:

EQUATION 11

$$\text{pr}(v_i = 1) \mid X = F\,(a + \beta_1 PriorPerformance_i + \beta_2 Student_i + \beta_3 School_i + \beta_4 Urbanizing_i + \varepsilon_i) = \frac{1}{1+e^{-(\alpha+\beta_1 PriorPerformance_i+\beta_2 Student_i+\beta_3 School_i+\ \beta_4 Urbanizing_i+\varepsilon_i)}}$$

This method matches on unobservable characteristics constant across the urbanizing districts in addition to the observable variables used in previous estimates. Table F7 in **Appendix F** displays the results. I only perform the analysis among the eighth grade population, as $Urbanizing_i$ almost perfectly predicts NCVPS participation among very early takers.[62]

Figure H4 displays the estimated distribution of propensity scores for traditional and NCVPS students from Equation 11. About 84.6% of traditional students fall between 0.0 and 2.5% probability (N=20,627; see blue bar farthest to the left). An additional 6.7% of traditional students fall between 2.5 and 5.0% probability (N=1,643; see blue bar second from the left). This leaves 8.7% of the control population with a propensity above 5.0% (N=2,099).

[62] Among very early takers, 81.2% of the students in urbanizing districts are in an NCVPS course, while 100.0% of the students in non-urbanizing districts are in a traditional course.

FIGURE H4: EIGHTH GRADE STUDENTS' PROPENSITY FOR NCVPS BY CLASSROOM TYPE WITH URBANIZING CONTROL

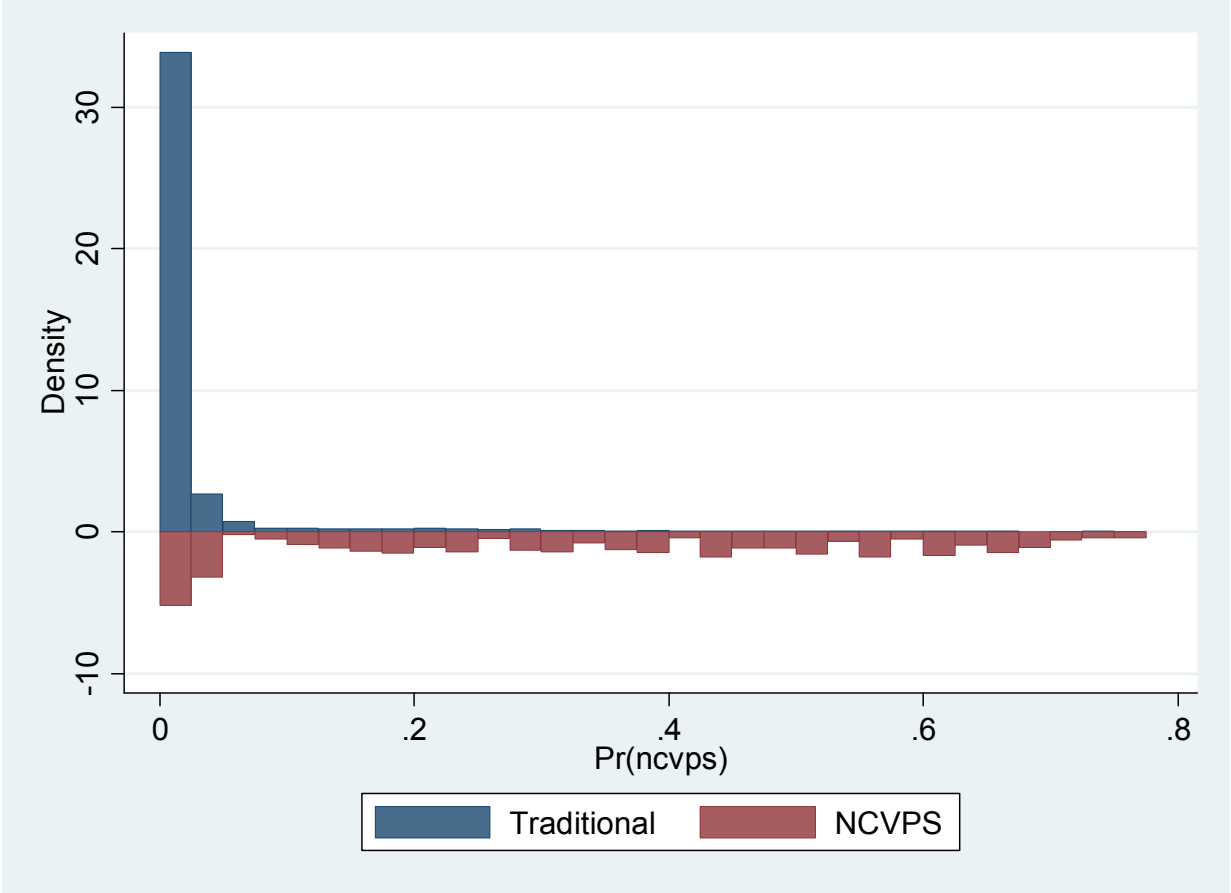


Figure H5 focuses on the students in the treatment and control groups with a predicted propensity above 5.0%. The figure shows that the majority of NCVPS students have a match with a traditional student with a similar estimated propensity for NCVPS. Overall, the propensity score for traditional students ranges from 0.0 to 74.8%, with a mean of 2.2%. The NCVPS propensity scores ranges from 0.0% to 76.6%, with a mean of 31.1%. Thus, only the NCVPS students at the highest propensity scores are off-support.

FIGURE H5: EIGHTH GRADE STUDENTS' PROPENSITY FOR NCVPS BY CLASSROOM TYPE WITH URBANIZING CONTROL (5-100%)

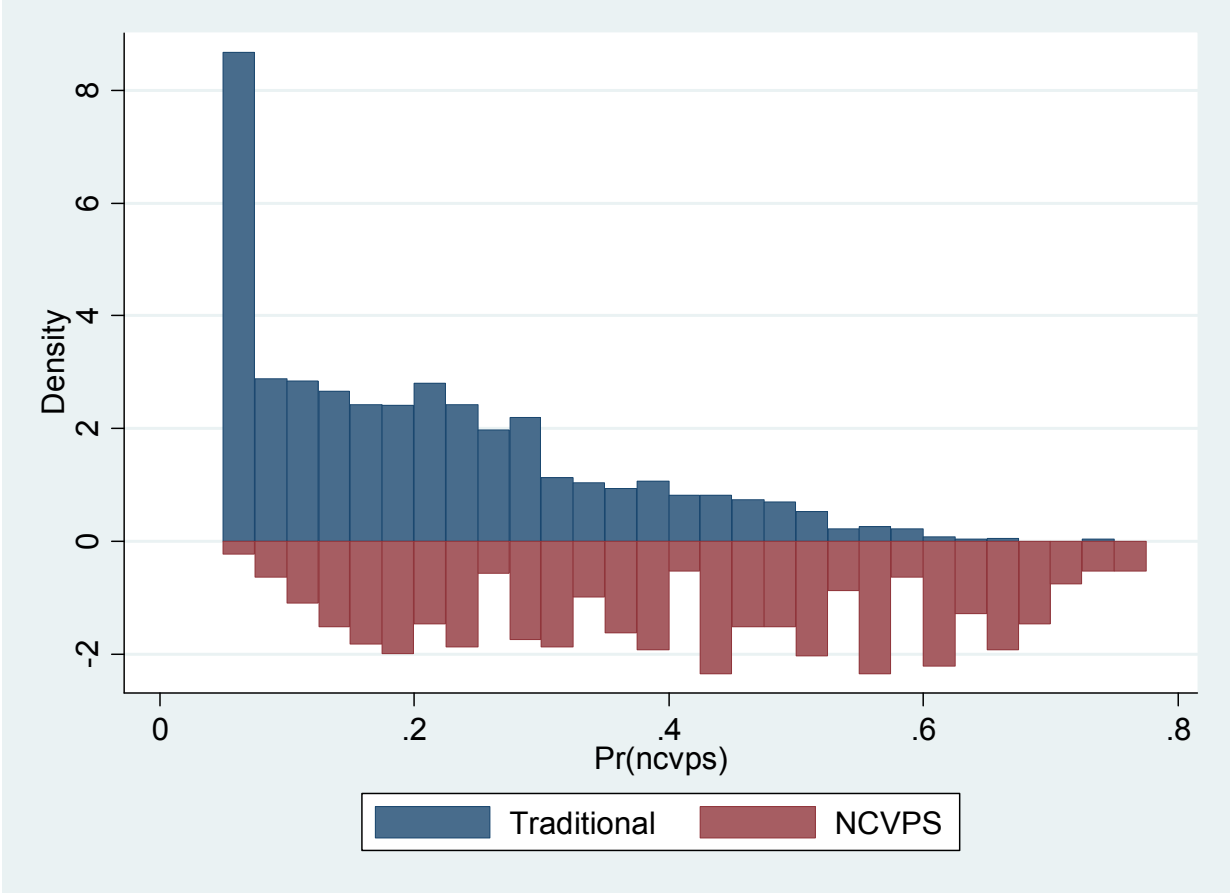


Table H3 displays the estimated Z-score and passing rate gaps under the matching methods. Both nearest neighbor and radius matching finds no statistically significant difference between NCVPS and traditional students for the Z-scores; this confirms previous results. The passing rates are no longer statistically significant. The passing rates among these positively selected students are about 99.0%, so little variance exists. Overall, the analysis confirms that eighth grade students perform about the same in either system.

TABLE H3: EIGHTH GRADE MATCHING RESULTS WHEN CONTROLING FOR URBANIZING DISTRICTS

	Z-Scores	Passing Rates
5 Nearest Neighbors	-0.062	-0.669%
	(0.039)	(0.039)
0.01 Radius Matching	-0.023	0.677%
	(0.036)	-0.491

** p<0.05, **p<0.01, *** p<0.001*

4. SUB-SECTION SUMMARY

A verification strategy that replaces the Algebra I EOC standardized test score with the students' fifth grade math standardized EOG results found no statistical difference between NCVPS

and traditional students among the eighth grade students using the matching methods. If NCVPS systematically differed from traditional students, the 2010-11 decision to pursue NCVPS may retroactively "predict" performance on prior exams due to unobservable differences.

The propensity score analysis results consistently demonstrate that eighth grade students perform about the same in traditional and NCVPS classrooms, while very early takers perform worse in NCVPS relative to similar traditional students. These results are robust to a variety of specification checks and confirm the results found in the OLS analysis.

B. DOUBLY ROBUST PROPENSITY SCORE MATCHING

Propensity score matching solves many of the problems associated with observational data. Moreover, Lunceford and Davidian (2004) show that augmenting a propensity-weighted estimate with regression analysis can increase precision. Remarkably, the method has a unique "double robustness" property; even if the researcher misspecifies the regression model, the estimator still produces an unbiased estimate of the average causal effect. I can use the propensity scores defined in the previous section to create a weight for each unit in the population, as follows:[63]

EQUATION 12

$$w_i = \begin{cases} 1 & if\ NCVPS = 1 \\ \dfrac{p_i}{1 - p_i} & if\ NCVPS = 0 \end{cases}$$

where p_i is the estimate propensity score. In the analysis, students with a high probability of pursuing NCVPS *but who took the class in a traditional brick-and-mortar setting* receive a higher weight than students with a low probability of pursuing NCVPS. I complete the analysis separately for very early takers and eighth grade students, given their distinct propensity results from the previous section. This methodology balances students across all control variables.

The results are not substantially different from those in previous analysis and are not described here. The full results are available in Table F8 in **Appendix F**. In the final regressions, very early takers underperformed relative to traditional students by 0.254 standard deviations (p-value=0.006), while the gap between eighth grade students in NCVPS and traditional classrooms is statistically insignificant (β_1=0.034, p-value=0.193).

C. LOGIT ANALYSIS OF STUDENT PASSING RATES

The OLS results provide information on students' relative performance, but they may be somewhat biased. Improved EOC test scores do not benefit students as much once they hit the passing threshold; thus, the incentives students face differ along the performance curve. To address this concern, I can examine rates of passing between NCVPS and traditional students using the following baseline logistic regression:

[63] This method provides the average treatment effect on the treated (ATT). Other weighting methodologies provide the treatment on the control or the average treatment effect. I use ATT for consistency with the matching methodology.

EQUATION 13

$$\text{pr}(pass_i = 1) \mid X = F\,(a + \beta_1 NCVPS_i + \varepsilon_i) = \frac{1}{1+e^{-(\alpha+\beta_1 NCVPS_i+\varepsilon)}},$$

where $pass_i$ is an indicator variable of whether student i passed the Algebra I EOC test and the other variables are as indicated above. I progressively add control variables and the interaction term to the baseline logit regression in the same order as in the OLS regression series. For prior performance, I use student i's standardized previous score and a square of the standardized previous score; various measures of model fit indicate that the squared term fits the data better than the decile format used in the OLS estimation.[64]

Table F5 in **Appendix F** presents the results for the Algebra I passing analysis. The baseline regression results indicate a positive relationship between NCVPS and passing, although the effect is not close to statistical significance (p-value=0.185). When controlling for the students' previous performance, the effect is positive and closer to statistical significance (p-value=0.155). As expected, a greater demonstrated ability on the previous EOG test is associated with a greater probability of passing the Algebra I EOC test, although the benefits are lower at higher levels of previous scores.

The third column displays the results with the individual-level controls. The estimated relationship between NCVPS and passing rates is positive and closer to statistical significance (p-value=0.105). The controls are somewhat interesting. Notably, very early takes (grades 6-7) have a lower probability of passing than eighth grade students, although again the difference is not statistically significant (p-value=0.151). The coefficients on nonwhite, AIG-math, and LEP status are not statistically significant, while non-FRL, female, AIG-reading, and non-EC students have higher probabilities of passing. The results are similar when controlling for school-level characteristics in the fifth column, with students in charter schools having a higher probability of passing.

The interaction term in the final column paints a more nuanced picture. Figure H6 summarizes the results for a typical student by grade.[65] Based on this model, NCVPS students pass the Algebra I EOC test at a somewhat higher rate than similar traditional students, and eighth graders pass at a somewhat higher rate than young students. However, none of these differences are statistically significant, which is unsurprising given the high probability of passing among positively selected middle school Algebra I students.[66] Very few students in the population failed the course. Overall, logit analysis of passing rates offers provide little insight into the efficacy of NCVPS.

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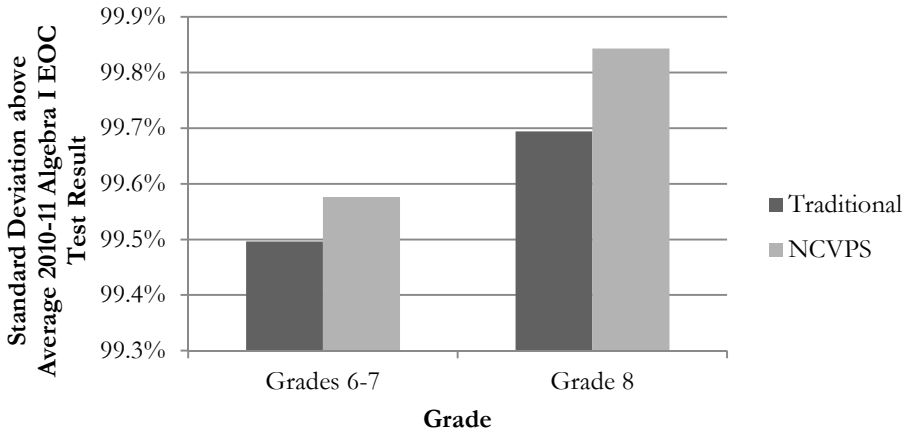
[64] The pseudo R-squared, AIC, and BIC scores are all higher in models with the squared term than in the same models with the indicators for previous decile of performance.

[65] A typical student is a rural male that has no AIG, EC, FRL, or LEP status attending a school with 50% FRL students. I use a previous EOG score of 1 standard deviation above the mean; the average for the population is 0.933 standard deviations. A typical student is displayed as an illustrative example; the model predicts the general trend to hold across all student types.

[66] Including *Urbanizing* does not substantially change results. A model limiting the population to *only* urbanizing districts (N=1952) indicates that very-early takers in NCVPS pass with less frequency than traditional students. For a typical student, the estimate is a 99.8% v. 100.0% passing rate. Again, the differences are not practically relevant. A typical

FIGURE H6: REGRESSION ESTIMATES FOR FINAL LOGIT REGRESSION



D. PANEL DATA ANALYSIS

The OLS estimates demonstrated that students' past performance predicts their future success. However, a variety of factors can affect any given test, and the Algebra I EOC test result is just the most recent in a series of math tests for these students. Students may have been on a particular trajectory (up or down) even before they entered their Algebra I course; Figure 11 displays the average trajectory for eighth grade students in Algebra I. Using all available previous scores for a given student allows a statistical technique that controls for the individual-level constants in each student. The model is written as follows:

EQUATION 14

$$score_{ig} = \beta_0 + \beta_1(v_{ig}) + \alpha_i + \tau_g + \varepsilon_i,$$

where $score_{ig}$ is student i's Z-score on the EOG or EOC test in grade g (g = 3, 4,…,8), v_{ig} is an indicator variable equal to one in the final grade if the student used NCVPS for Algebra I, α_i is a vector of student fixed effects, and τ_g is a vector of grade fixed effects. Thus, β_1 gives the estimate of the NCVPS treatment effect on the Algebra I EOC test result, holding student-level and grade-specific effects constant. The model controls for characteristics that stayed constant within students over time or that equally affected all students in the sample schools in a given grade.[67] It does not control for changes that occur only in certain students. I separately estimate a specification for seventh and eighth grade students. This allows me to compare students on the same series of tests.[68]

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student is a rural male with no AIG, EC, FRL, or LEP status attending a school with 50% FRL students with a previous EOG score 1 standard deviation above the mean; the average for the population is 0.933 standard deviations. A typical student is displayed as an illustrative example; the model predicts the general trend to hold across all student types.

[67] The model thus does not control for variables that are fairly stable across time such as school, race, FRL status, etc.

[68] An eighth grade Algebra I student would have taken her sixth grade EOG-math test in 2009, while a seventh grade Algebra I student would have taken her sixth grade EOG-math test in 2010. The tests vary somewhat year-to-year, and separating the analysis allows a comparison within the same testing series.

A summary of the seventh and eighth grade results are displayed in Tables H4 and H5. Tables F9 and F10 in **Appendix F** provide complete results. Columns (1) – (3) contain the estimates for the model where missing results have been estimated at the population average for a given test in a given year. Columns (4) – (6) contain the estimates when I exclude the students with missing values. Columns (1) and (4) contain individual student data for five grade levels. Columns (2) and (5) contain the data for four grades, and columns (3) and (6) contain data for three grades. Moving from left to right in each of the column sets, the data contain fewer grades but also fewer missing data points.

Seventh grade students in NCVPS score about 0.25 standard deviations lower than similar students in traditional classrooms, holding previous results constant. In eighth grade, the estimates indicate that NCVPS students score 0.05-0.08 standard deviations higher than traditional students, although the difference is not statistically significant.[69]

TABLE H4: SEVENTH GRADE PANEL DATA RESULTS (SUMMARY)

	Full Inclusion Model			*Restricted Model*		
	(1) Z-Score	(2) Z-Score	(3) Z-Score	(4) Z-Score	(5) Z-Score	(6) Z-Score
Est. Effect of NCVPS	-0.251**	-0.243**	-0.248**	-0.250**	-0.244**	-0.249**
	(0.089)	(0.089)	(0.088)	(0.090)	(0.090)	(0.088)
N (Total Unique Students)	2,968	2,968	2,968	2,923	2,933	2,942
Percent of Restricted 7th Grade Population	100.0%	100.0%	100.0%	98.5%	98.8%	99.1%
R^2	0.2294	0.2542	0.2704	0.2268	0.2522	0.2686

Standard errors in parentheses

** p<0.05, **p<0.01, *** p<0.001*

TABLE H5: EIGHTH GRADE PANEL DATA RESULTS (SUMMARY)

	Full Inclusion Model			*Restricted Model*		
	(1) Z-Score	(2) Z-Score	(3) Z-Score	(4) Z-Score	(5) Z-Score	(6) Z-Score
Est. Effect of NCVPS	0.052	0.062	0.083	0.053	0.063	0.083
	(0.062)	(0.064)	(0.070)	(0.063)	(0.065)	(0.070)
N (Total Unique Students)	25,246	25,246	25,246	24,785	24,871	24,991
Percent of Restricted 8th Grade Population	100.0%	100.0%	100.0%	98.2%	98.5%	99.0%
R^2	0.3131	0.3271	0.3441	0.3103	0.3251	0.3429

Standard errors in parentheses

** p<0.05, **p<0.01, *** p<0.001*

The results of the panel data analysis align with the findings in the OLS and propensity score matching methods. Specifically, eighth grade students perform about the same in either setting, while students in seventh grade fare worse in NCVPS. The difference of 0.25 standard deviations is policy-relevant; these students moved from about the 86th percentile in the traditional classroom to the 80th percentile in NCVPS.[70] The statistical similarity between NCVPS and traditional students is also policy-relevant. To argue that the results are caused by selection would imply that the 867

[69] Without school-level clustered standard errors, the results become statistically significant.

[70] Estimate based on the average traditional Algebra I seventh grade results of 1.10 standard deviations above the zero.

eighth grade NCVPS students' entire history of math tests fail to reveal a systematic difference that makes them better-suited to Algebra I. Instead, it seems that eighth grade students do well in either system.

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