Evaluating The Effectiveness of the North Carolina Virtual Public Schools System

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POLICY QUESTION: How does performance differ between students in North Carolina's Virtual Public Schools and traditional classrooms, and does this performance differ among low-income students?

EXECUTIVE SUMMARY

This paper examines the effectiveness of the North Carolina Virtual Public Schools (NCVPS). To do so, we examine the difference in passing rates on 2009-10 end-of-course tests between NCVPS and traditional classrooms. We control for a variety of student-level characteristics. When looking at average passing rates alone, students in traditional classrooms outperform those in NCVPS classrooms. However, different types of students may pursue each type of classroom, and we employ a statistical analysis to understand the difference between otherwise similar students. We also examine the socioeconomic status (SES) achievement gap between students with and without free and reduced price lunch (FRL).

Our results show that even when controlling for a variety of student-level characteristics, NCVPS students pass their end-of-course tests with less frequency than students in traditional classrooms. However, the analysis shows a smaller gap than that suggested by comparing the overall averages. In the FRL analysis, we found that NCVPS does not correspond with improvement in the SES gap between FRL and non-FRL students, and FRL students may fare worse in NCVPS. Future research should examine the less obvious characteristics of students who choose NCVPS (such as motivation) to understand the underlying cause of the differing results.

INTRODUCTION

HISTORY OF NCVPS IN NORTH CAROLINA

In 2002, North Carolina leaders realized we needed to change the way we educate students for them to be competitive in a global market. The NC General Assembly created the Business Education Technology Alliance (BETA) to ensure students learned 21st century skills to prepare them for success in secondary education and beyond. Under the leadership of then-Lieutenant Governor Beverly Perdue, BETA created North Carolina Virtual Public School (NCVPS) to provide students with more options in regard to scheduling and course offerings that their local schools may not have offered.

NCVPS staff indicated that schools offer virtual options for a variety of reasons: to offer classes to students ill at home, to provide a chance for students to take advanced courses, or to reduce traditional class sizes, among others. Each of these could lead different types of students to take the online courses. However, NCVPS does not always know why a school or a student has chosen to take a virtual course (M. Lourcey, personal communication, July 12, 2011).

As an example, a student may wish to take an AP course that is not available at their local high school. Generally, rural students tend to have fewer course offerings than students in other parts of the state. In contrast, NCVPS offers a multitude of classes free of charge to all students in North Carolina public schools no matter their geographic or economic limitations.

Other students choose NCVPS because of the flexibility it offers. For students who need to make up credits, NCVPS can be the difference between staying on track with peers or falling behind. For some, medical circumstances make attendance at school almost impossible. Instead of falling behind or dropping out, these students have an alternative that allows them to continue their coursework from home.

Currently NCVPS offers 21 AP courses, 25 World Language courses, 12 credit recovery courses, and 60 courses in math, English, science, social studies, art, career and technical education, and music. With over 100 course offerings, NCVPS supplied access to high quality educational materials and teachers for 45,000 course slots in 2010-11(M. Lourcey, personal communication, July 13, 2011). It also currently operates the second largest virtual public school in the United States, second only to Florida in the number of students served.

PREVIOUS RESEARCH ON EFFICACY OF VIRTUAL SCHOOLS IN OTHER STATES

A meta-analysis of the empirical literature on virtual education concludes that the effectiveness of virtual education depends on the specific conditions and settings of a given system. When dividing virtual education into synchronous and asynchronous applications, the outcomes differ (Bernard et al., 2004). Asynchronous teaching relies solely on the online platform to facilitate the learning process, while synchronous modes of communication involve teacher-student texting, emailing, and talking on the phone about course assignments and objectives. In mostly asynchronous courses, students study independently and must have strong internal motivation to complete the course of study. Alternatively, a blend of asynchronous and synchronous virtual education makes use of peer-to-peer interaction, collaborative learning, email, and online platforms, and through these learning modes, students tend to fare better than they would in solely asynchronous virtual education courses (Bernard et al., 2004).

Kember (1996) wrote that younger learners often feel the need to identify with and be included by a group to remain motivated and complete a task or course of study. Constant feedback, email, and phone interaction throughout virtual courses seeks to fulfill that need, and this feedback builds a young learner's confidence and encourages them to continue pursuing course completion.

With this said, Bernard (2004) has advised policymakers to use caution when evaluating virtual courses. Differences in implementation of virtual courses are common and may affect student groups in both positive and negative ways.

NCVPS POLICIES

NCVPS uses a combination of synchronous and asynchronous tools. Teachers frequently communicate with their students, and students can contact teachers throughout the day via phone calls, texts, emails, or instant messaging. Daily live tutoring chats provide another opportunity for students to receive assistance from their teachers, and teachers can provide homework and test feedback via email or voice messages. Teachers must contact parents at least once a week. Thus, NCVPS offers students, teachers, and parents many forums to interact.

Oliver et al. (2009a) found that NCVPS offered students increased flexibility and responsibilities, expanded opportunities, and individualized instruction and support. However, some problems existed for student readiness; students did not always have the technical skills or resources for online learning and many lacked self-direction. However, NCVPS continually expands and improves its course offerings and course content to address problems. For instance, teachers unveiled a revamped EOC test preparation content in all EOC courses in the spring of 2011. Oliver et al. (2009b) found that NCVPS has increased in rigor, individualization, and student success from prior years, while technical problems decreased. With continued monitoring and support NCVPS can continue to improve.

SOCIOECONOMIC STATUS, TEACHER QUALITY, AND STUDENT ACHIEVEMENT

Students with low socioeconomic status (SES) generally have lower academic performance than their peers for a variety of reasons (Clotfelter, Ladd, & Vigdor, 2010; Rothstein, 2004). This difference has been fairly consistent over time; Reardon and Robinson (2008) estimate that this "SES achievement gap" in 2004 was about equal to the gap in the early 1980's.

Differences in teacher quality could contribute to the SES achievement gap. The least-qualified teachers frequently stand in front of the students who most need educational assistance. North Carolina students in high-poverty high schools have teachers with much lower qualifications than those in more affluent schools on average, and these differences systematically affect student achievement (Clotfelter et al., 2010). In particular, high-need rural schools struggle to attract and retain highly qualified teachers for a variety of reasons (Sipple & Brent, 2008).

NCVPS attempts to provide low-income students with highly qualified teachers to address the SES achievement gap by carefully selecting teachers who have a record of academic success in their face-to-face classrooms. These teachers then participate in an 18-week program where they work with an experienced NCVPS teacher to learn and master the online course delivery format. Only the best teachers are given teaching sections in NCVPS. Through this careful vetting process, NCVPS seeks to select only the most qualified teachers for their courses and improve the overall quality of courses provided to students.

DATA[1]

We used data from a variety of sources to evaluate the efficacy of NCVPS, including the Department of Public Instruction's Accountability Services Division and Enterprise Development and Reporting, North Carolina Virtual Public Schools, the North Carolina School Report Card database, and the National Center for Educational Statistics. Our analysis examined the probability of a student passing the Algebra I, English I, Civics & Economics, and Physical Science end-of-course (EOC) tests in the 2009-10 school year. We focused on courses with EOC tests because we needed a method to evaluate student performance. EOC test results allow us to compare students in NCVPS and traditional classrooms.

We limited our analysis to traditional public high schools to more accurately examine the experience of a typical student. To allow a comparison between traditional public school classrooms and NCVPS, we excluded charter and special education schools, as well as courses taken at a Juvenile Justice or Health and Human Services location. We collected data for the 2009-10 school year, as data from prior periods contained a variety of coding errors. We ultimately had four separate data sets: one for each of the test results we examined.

DESCRIPTION OF NCVPS STUDENTS

NCVPS students perform differently than students in traditional classrooms. Table 1 provides a comparison of traditional and NCVPS students in Algebra I and English I. The students in traditional courses average higher scores on their respective EOC tests and pass with greater frequency. Given this information, it may appear that NCVPS courses are in some way not as successful as traditional courses.

However, NCVPS students differ from traditional students in their baseline characteristics. More NCVPS students applied for free and reduced price lunch (FRL), more are identified as exceptional children (EC), and fewer are identified as academically or intellectually gifted (AIG). Based on our data, these groups pass the EOC tests with different frequencies in both NCVPS and traditional classrooms. Differences in the distribution of students between traditional and NCVPS courses may lead to a difference in the proportion of students passing and failing EOC tests in each course type on average. To more fully understand the efficacy of the NCVPS program, a statistical analysis must take these variations into account.

Additionally, NCVPS students are also more likely to be minorities in Algebra I and males in English I. NCVPS students live in a rural areas and towns with greater frequency than traditional students, while traditional students are more likely to live in a suburb or city than NCVPS students. Notably, the high proportion of students taking NCVPS in rural areas marks a success in one of the program's key missions: expanding course offerings to rural students.

TABLE 1: DESCRIPTIVE STATISTICS FOR ALGEBRA I AND ENGLISH I STUDENTS (2009-10)

School Outcomes & Characteristics	Traditional Algebra I Students	NCVPS Algebra I Students	Traditional English I Students	NCVPS English I Students
Average Score	154.1	147.6	152.7	145.5
% Passing	78.4%	45.6%	83.3%	51.5%
% FRL	47.2	52.9	46.4	69.5
% Male	50.6	52.3	51.1	60.3
% Minority	46.2	52.9	45.0	50.4
% EC	10.2	15.3	10.7	22.9
% AIG	17.1	7.6	17.3	3.9
School Location				
% Rural	49.0	55.9	49.2	52.6
% Town	11.9	20.2	11.9	22.6
% Suburb	14.3	6.3	14.4	5.6
% Urban	24.8	17.6	24.5	19.2

Highlighted cells indicate statistically significant differences.[2]

[1] *For more detailed information on our data sources, please see Appendix I.*

[2] *This analysis uses a two-sided t test at the 10% significance level.*

METHODOLOGY[3]

We used two logit regression models to examine students' performance in NCVPS courses, using students in traditional classrooms as a comparison group. Our models examined the relationship between taking a NCVPS course and the probability of a student passing an EOC test. Model 1controls for the following variables:

- Course type (regular, advanced[4], or credit recovery)
- Student characteristics (whether a student applied for FRL, sex, minority status, grade level, EC status, and AIG status)
- School location (rural, town, suburban, or city)

NCVPS strives to provide access to high quality courses to all students across the state. In particular, poor rural students should have the same opportunities as their more affluent peers in the suburbs. As noted above, FRL students generally have lower scores than their more affluent peers. However, the achievement gap should not be worse in NCVPS than in traditional courses – and, given the emphasis on providing highly qualified teachers to rural students through NCVPS, the gap in NCVPS should perhaps be better. Thus, Model 2 examines the relationship between FRL and success in NCVPS.

It became clear from Model 1 that the factors that affect success for students in advanced and credit recovery (CR) courses differ from those in regular courses. We therefore limited the data to regular course types to simplify the analysis. Data limitations prevented a deeper examination of advanced and CR courses; future research should examine NCVPS more closely in these areas. Model 2 also controlled for the other factors listed for Model 1.

Both models estimate the effect of the NCVPS program by comparing students whose control characteristics are otherwise the same. A positive result indicates that students are more likely to pass an EOC test in NCVPS than in a traditional classroom. A negative result indicates that students are less likely to pass in NCVPS.

THE IMPORTANCE OF STUDENT CHARACTERISTICS

Notably, the EOC test passing rates for advanced courses are often higher, but the cause is not necessarily a difference in the quality of education the advanced students receive. Rather, different sorts of students choose to pursue more difficult courses, which also contributes to higher passing rates. Similarly, different sorts of students take credit recovery courses, and those differences lead to lower passing rates among CR courses. However, we can make a comparison within these groups using EOC test passing rates, because everyone takes the same test regardless of the course difficulty.

The models controls for observable differences in students such as FRL status and sex, but they cannot control for unobservable differences in why students take NCVPS courses. If more motivated students pursue NCVPS courses, then we would likely see higher passing rates through NCVPS. If students who dislike English take the course online because they hope it will be easier, then we would likely see lower passing rates through NCVPS. Without analyzing these patterns, it will be difficult to understand the underlying reasons for differences between NCVPS and traditional classrooms.

[3] *For more detailed information on our data sources, please see Appendix II.*

[4] *Advanced courses include Advanced Placement (AP), International Baccalaureate (IB), honors, and other advanced courses. More information on the identification of these courses can be found in Appendix II.*

[5] *For more detailed information on our data sources, please see Appendix III.*

[6] *In this case, typical indicates a student without an IEP, without AIG status, without free or reduced lunch, taking a course in the most common grade. We use these attributes because the largest proportion of students shares these characteristics.*

RESULTS[5]

Because our analysis cannot account for unobservable characteristics such as motivation, our results are descriptive and not necessarily prescriptive. That is, the results describe the differences between NCVPS and traditional students, but the reason for the differences will not necessarily be NCVPS itself. However, the models provide interesting insight into current EOC proficiency patterns.

MODEL 1: OVERALL RESULTS

For most subjects and course types, the probability of passing an EOC test is significantly lower among students who took the same course through NCVPS. However, several exceptions exist. Table 2 displays the differences in the expected rates of passing between NCVPS and traditional courses for regular, advanced, and CR courses. The rates displayed are for a typical[6] female student, and statistically significant differences are highlighted.

As an example, the model predicts that a typical 9th grade female student in a regular English I course passed her EOC test 92.5% of the time in a traditional classroom. A similar girl in a NCVPS course passed the same EOC test 85.6% of the time, a difference of -6.9 percentage points. In an advanced course, 98.7% of typical female students passed the EOC test, while only 92.3% passed in the NCVPS class, a difference of -6.4 percentage points. The trends reversed in CR courses, with 77.9% of typical female students passing the EOC test in the traditional course and 84.8% passing in the NCVPS course, a difference of 6.9 percentage points.

The model predicts significantly lower rates of passing the EOC test in NCVPS courses than in traditional courses in regular

classes for all four courses. For the two courses with advanced NCVPS options, the students in traditional courses also outperformed their NCVPS peers.

In credit recovery courses, no statistical difference appeared for Algebra I and Physical Science. As mentioned above, NCVPS students in English I outperformed students in traditional classrooms. Conversely, traditional students outperformed NCVPS students in Civics & Economics.

We used a typical female student to highlight results in this section. Changing the student demographics would affect the specific pass percentages; for instance, all pass rates in both NCVPS and traditional classrooms would be lower if we specified a comparison among FRL students. However, no matter what grade, sex, race, FRL/EC/AIG status, or other control characteristic we specified in the model, the statistical significance and the direction of the results would remain the same.

TABLE 2: MODEL 1 ESTIMATED PASSING RATES BY COURSE TYPE FOR A TYPICAL FEMALE STUDENT

	Algebra I			English		
Course Type	**NCVPS**	**Traditional**	**Difference**	**NCVPS**	**Traditional**	**Difference**
Regular Course	77.7%	88.9%	-11.2%	85.6%	92.5%	-6.9%
Advanced Course	N/A	92.7%	N/A	92.3%	98.7%	-6.4%
CR Course	68.5%	69.1%	-0.6%	84.8%	77.9%	6.9%

	Civics & Economics			Physical Science		
Course Type	**NCVPS**	**Traditional**	**Difference**	**NCVPS**	**Traditional**	**Difference**
Regular Course	63.7%	83.2%	-19.6%	76.5%	89.8%	-13.4%
Advanced Course	93.0%	97.8%	-4.7%	N/A	92.5%	N/A
CR Course	49.7%	52.9%	-3.2%	47.1%	25.8%	21.3%

Highlighted cells indicate statistically significant results.[8]

[7] *Though the difference appears large, it is not statistically significant due to the small number of traditional CR Physical Science EOC's in the sample (n=19).*

[8] *This analysis uses a hypothesis test to confirm statistical differences at the 10% significance level.*

TABLE 3: MODEL 2 ESTIMATED PASSING RATES BY COURSE TYPE FOR A TYPICAL MALE STUDENT

	Algebra I			English		
	NCVPS	Traditional	Difference	NCVPS	Traditional	Difference
Non-FRL	75.8%	88.0%	-12.1%	76.9%	89.4%	-12.5%
FRL	66.4%	81.7%	-15.3%	69.3%	81.5%	-12.3%
Difference	9.5%	6.3%	3.2%	7.6%	7.9%	-0.3%

	Civics & Economics			Physical Science		
	NCVPS	Traditional	Difference	NCVPS	Traditional	Difference
Non-FRL	70.9%	87.5%	-16.5%	82.2%	90.5%	-8.3%
FRL	61.7%	81.5%	-19.8%	62.2%	86.8%	-24.6%
Difference	9.2%	6.0%	3.2%	20.0%	3.8%	16.3%

Highlighted cells indicate statistically significant results.[10]

MODEL 2: FREE & REDUCED PRICE LUNCH RESULTS

Table 3 displays the differences in the expected rates of passing the EOC test between NCVPS and traditional courses for FRL and non-FRL students. The rows compare NCVPS and traditional rates, while the columns compare FRL and non-FRL rates. The rates displayed are for a male student[9], and statistically significant differences are highlighted.

As predicted by previous research, typical male FRL students passed their exams with less frequency than non-FRL students in both NCVPS and traditional classrooms. Further, all students (whether FRL or non-FRL) performed better in traditional courses than on NCVPS, as predicted by Model 1. However, the achievement gap between FRL and non-FRL students in each course type was about the same.

For instance, 7.6 percentage points fewer male FRL students passed the English I EOC test through the NCVPS classroom. The gap was 7.9 percentage points in the traditional classroom. Thus, the gap was about the same between the two.

The difference in the gap was 16.3 percentage points for Physical Science. This demonstrates that, controlling for the factors in Model 2, the gap between FRL and non-FRL students was substantially larger in NCVPS than in non-NCVPS courses.

The difference in the gap was 3.2 percentage points for both Algebra I and Civics & Economics courses, but the gap was statistically insignificant.

As in Model 1, we used a typical student to highlight differences between NCVPS and traditional classrooms, but the statistical significance and the direction of the results would remain the same regardless of the demographics we specified.

THE RELATIONSHIP BETWEEN PREVIOUS STUDENT OUTCOMES AND SUCCESS IN NCVPS

We briefly examined the relationship between past performance on eighth grade end-of-grade (EOG) tests and performance in Algebra I and English I EOC tests[11], which are typically taken in ninth grade. We also examined suspension data to examine whether students with a history of discipline problems were more or less likely to pursue online education. Due to the inconsistent use of a unique identifier for students between 08-09 and 09-10, the results in the following section should be interpreted with caution[12].

When we compare students with similar past performance, the difference between NCVPS and traditional classrooms disappears for English I and remains about the same for Algebra I. These results have two significant implications:

First, the models may indicate that the NCVPS English I course educates students at the same level as traditional classrooms, but differences in student characteristics affect test outcomes. Together with the results from the previous section, the results indicate that NCVPS English I may offer a successful alternative to the traditional classroom. We cannot say the same for NCVPS Algebra I without understanding more about the students.

[9] *As in the previous example, typical indicates a student without an IEP, without AIG status, without free or reduced lunch, taking a course in the most common grade. The largest proportion of students shares these characteristics.*

[10] *This analysis uses a hypothesis test to confirm statistical differences at the 10% significance level.*

[11] *We focused on Algebra I and English I because they correspond more directly to the eighth grade math and reading EOG test, respectively, to a greater extent than Civics & Economics and Physical Science. A lack of data prevented us from using the eighth grade science EOG.*

[12] *The statewide unique identification (UID) student system was in full operation at the start of the 2009-10 school year. In 2008-09 there was no consistent UID between student data collection systems, and North Carolina did not have a statewide means of tracking student data.*

Second, NCVPS courses serve a larger proportion of students with a history of not meeting proficiency standards in related courses than traditional courses. Based on our data, students taking Algebra I through NCVPS passed their eighth grade math EOG test less frequently than students who took Algebra I in a traditional classroom. Students taking English I through NCVPS passed both their eighth grade math and reading EOG tests less frequently than students taking English I in a traditional classroom. Thus, it appears that students who have demonstrated academic difficulties in the past are more likely to take online education than proficient students.

We also found interesting trends with student discipline data. We specifically examined the relationship between number of days suspended in 2008-09 and EOC test results in 2009-10. We found no difference in the suspension days between NCVPS and traditional students in Algebra I or Physical Science, while NCVPS students had more suspension days than traditional students in English I and Civics & Economics. Further, it appears that previous behavioral problems are associated with lower performance on EOC tests in all four subjects.

Overall, preliminary EOG test and discipline results could indicate that some "problem" students are more likely to be placed in NCVPS, either by the choice of the students, their parents, or the schools. Notably, data problems prevented us from pursuing this trend in more depth. We could not match many of the students' unique IDs to their previous EOG test results or discipline data , which prevented us from producing a complete analysis. The results in this section should be interpreted with caution. Future efforts should ensure that all schools and DPI departments consistently tie student unique IDs to student data to prevent this problem.

CONCLUSION

North Carolina has established one of the premier virtual school systems in the country. The program serves thousands of students every year and expands access to rural students. NCVPS courses also incorporate both asynchronous and synchronous modes of learning, and based on prior research this hybrid method stimulates student learning and produces positive outcomes, such as higher pass rates.

However, our results show that even when controlling for a variety of student-level characteristics, NCVPS students in regular or advanced courses passed their EOC tests with less frequency than students in traditional classrooms in 2009-10. Notably, the gap appears smaller than that suggested by a simple comparison of averages, but the difference remains substantial. Still, NCVPS provides an important alternative for many students. Benefits such as scheduling flexibility, expanded course offerings, smaller class sizes, and accelerated learning opportunities, among other areas, provide considerable benefits to students and schools.

We found mixed results for credit recovery courses. Compared to traditional students in CR courses, NCVPS students in CR courses perform better than traditional students in credit recovery courses in English I, worse in Civics & Economics, and about the same in Algebra I and Physical Science. English I students may benefit from the self-paced options in NCVPS, but our data cannot confirm this hypothesis. It remains unclear why that would differ from the other subject areas. Students, teachers, the school, and the state may also benefit from the online environment's self-pacing, opportunity to stay on track, and cost savings, among other things. Thus, NCVPS could present a desirable option over traditional credit recovery courses even in courses where results are about the same.

In the FRL analysis, we found that NCVPS does not correspond with an improvement in the SES achievement gap, and the gap actually expands in Physical Science courses. Thus, it does not appear that NCVPS has succeeded in closing the gap between poorer students and their more affluent peers in our four subject areas.

POTENTIAL EXPLANATION FOR NCVPS RESULTS

Many factors could influence the difference between NCVPS and traditional classrooms, but we believe these factors fall into three over-arching categories: outside factors (such as schools and parents), the students themselves, or the NCVPS system. We explore these areas below.

- ***NCVPS students may not receive the support they need from their schools or families.*** Students need computer access during the day and at home, as well as parent involvement to ensure task completion. Without this support, students will likely struggle in their NCVPS courses. Our research found some evidence of greater differences between FRL and non-FRL students in NCVPS than in traditional classrooms, particularly in Physical Science. Perhaps lower-income students have less support in general, and NCVPS exacerbates pre-existing problems to some extent.
- ***Students who choose NCVPS may differ from those in traditional courses in unobservable ways such as motivation.*** For instance, students who dislike a particular course may opt to take the course online, and their initial lack of interest may lead to lower passing rates for NCVPS. Students using NCVPS because of illness may also have lower passing rates than other students as they focus on their health. By controlling for observable differences, we did find a reduced difference between

[13] *We could not match the eighth grade EOG data to 2009-10 EOC test results for 23.5% of our Algebra I students or 8.2% of our English I students. Thus, results should be interpreted with caution.*

[14] *We could not match 2008-09 discipline data to 2009-10 EOC test results for 57.8% of our Algebra I students, 78.5% of our English I students, 80.0% of our Civics & Economics students, or 73.4% of Physical Science students. Thus, results should be interpreted with caution.*

NCVPS and traditional courses, and it seems plausible that students who choose a virtual environment may differ from those who do not in unobservable ways.

- ***NCVPS may not provide the instructional methodology, structure and/or materials that high school students need.*** If this were the case, changes may need to be made to the system. As an example, perhaps certain high school students lack the discipline to complete courses in front of a computer and need more support. Or, if students lack necessary lab equipment at home or school, they may have a more difficult time excelling in a science course. Unfortunately, data limits prevented us from examining this possibility in more depth.

POLICY RECOMMENDATIONS

Each possible area requires very different policy corrections. For example, schools may need to expand their computer lab hours if students lack support at home, but expanded hours may not help if the students do not use them. Future research should examine the underlying cause of outcome differences between NCVPS and traditional students to ensure a full understanding of any issues affecting performance. Further, proven virtual education techniques may improve student performance. We recommend the following:

- ***Survey students.*** A required pre-enrollment survey could provide vital information about student characteristics and needs. NCVPS could use the results to identify the sorts of students who excel in a virtual environment and improve instructional personalization. Requiring the survey before enrollment would allow NCVPS to compare results for all students, including those who drop out.
- ***Survey parents and schools.*** Such a survey could examine the support students receive. Moreover, understanding the reasons why a school chooses to provide NCVPS support could provide valuable insight. A school using NCVPS to reduce class size differs from a school using NCVPS to offer classes not available at the school, and the needs of students will differ accordingly.
- ***Expand synchronous teaching time.*** Currently tutoring only occurs during a one hour period once or twice a day. Teachers share the responsibility of running the tutoring, which means students may only have one or two hours a week to attend a class-like session with their assigned teacher. Students may have conflicts (such as a pre-scheduled face-to-face class) that prevent them from attending all sessions. Expanding the opportunities for students and the teacher to come together virtually may improve student outcomes, particularly if students are not inclined to seek out the teacher for assistance.
- ***Use more videos to improve teaching.*** Students may benefit from seeing a teacher point to a topic on the board while hearing an explanation. Currently, many teachers leave voice and written messages for students, but the combination of seeing and hearing may improve student understanding.

- ***Use technology to improve student access.*** As an example, Algebra I requires an advanced graphing calculator, so NCVPS developed an online calculator for students to use. NCVPS should search for more areas to improve access, such as making books available online.
- ***Focus website design for digital natives.*** Many students grew up with technology, and a streamlined design may be more effective than the personalized, multi-colored layout currently employed.

Notably, the Friday Institute has conducted NCVPS surveys in the past; DPI should target future surveys towards understanding the performance differences between NCVPS and traditional classrooms. Further, NCVPS should pursue methods to ensure survey completion to maximize knowledge gained. Only 18.9% of students filled out a recent NCVPS survey; only 5.0% of principals completed theirs (Oliver, et al., 2009b).

North Carolina has a valuable virtual schools system. Continual monitoring and targeted improvements will ensure its sustained viability by constantly adapting to the needs of a growing and changing student population. Understanding the underlying motivations and characteristics of schools and students pursuing virtual education will maximize academic benefits and improve education in North Carolina.

APPENDIX I: DATA

Our data included four independent data sets: one each for Algebra I, English I, Civics & Economics, and Physical Science. Our data points were individual students who took an EOC test in one of these courses in 2009-10. Prior coding errors limited our ability to examine previous years, and evolving technology meant that 2009-10 provided a more accurate picture of current NCVPS course outcomes than previous data. The Accountability Services Division of DPI provided enrollment information for non-NCVPS courses and EOC test data for all students. They also provided FRL, sex, race, grade, IEP, and local school information. NCVPS provided NCVPS enrollment information. Problems with matching student ID's to identifying information in NCVPS led us to drop some students. We compiled student AIG status from Enterprise Development and Reporting, and we used National Center for Educational Statistics (NCES) codes to identify rural, town, suburban, or city status.

We identified course type (regular, advanced, and credit recovery) using the course title and course code. Course title and codes vary by district, particularly in NCVPS, and it is likely that some misidentification occurred. We coded as conservatively as possible; we defaulted to identifying a course as regular without a clear and consistent reason to do otherwise. This process should limit our coding errors. Our results would likely be more pronounced with more accurate coding, because miscoded courses would not dilute the differences between the groups.

We limited our analysis to traditional public schools. To ensure the best comparison, we excluded charter and special education schools, as well as courses taken at a Juvenile Justice or Health and Human Services location. We also excluded schools missing any of the control variables and students in traditional courses that appeared to have an online component (e.g., NovaNet). This allowed a more accurate comparison between NCVPS courses and traditional classroom settings. We were left with 113,238 Algebra I EOC test scores, 107,732 English I EOC test scores, 101,084 Civics & Economics test scores, and 50,760 Physical Science EOC test scores.

APPENDIX II: METHODOLOGY

MODEL 1: OVERALL ANALYSIS

We used the following logit analysis to estimate the efficacy of the NCVPS program overall:

$$\text{logit}(\text{pass}_i) = \beta + \text{NCVPS}_i + \text{AP}_i + \text{NCVPS}_i{*}\text{AP}_i + \text{CR}_i + \text{NCVPS}_i{*}\text{CR}_i + \text{FRL}_i + \delta_i + \lambda_i + \epsilon_i ,$$

where pass is an indicator variable of whether the individual student *i* passed a given course, β is the constant, NCVPS is an indicator variable of whether a student took the course as NCVPS, AP is an indicator for whether a course was advanced, CR is an indicator for whether a course was taken as credit recovery, FRL is an indicator for whether student *i* applied for free or reduced price lunch, δ is a vector of student characteristics (sex, race, grade, IEP, and AIG status), λ is a vector of the school's location (rural, town, suburb, or city), and ϵ is the error term.

The model also includes two interactions: NCVPS*AP and NCVPS*CR. The coefficient on NCVPS provides information on whether passing rates differ between NCVPS and traditional classrooms in regular courses (the NCVPS/traditional course gap). The interactions provide details on whether the difference in passing rates differs by the specific course types (advanced or CR). If the interactions are insignificant, all three types (regular, advanced, and CR) have the same NCVPS/traditional course gap. If an interaction is significant, it indicates a difference in the NCVPS/traditional course gap between these groups.

MODEL 2: FREE & REDUCED PRICE LUNCH ANALYSIS

We used the following logit analysis to estimate the relationship between NCVPS and FRL in regular classes:

$$\text{logit}(\text{passi}) = \beta + \text{NCVPS}_i + \text{FRL}_i + \text{NCVPS}_i{*}\text{FRL}_i + \delta_i + \lambda_i + \epsilon_i ,$$

where the variables are the same as above. The model adds an interaction of NCVPS*FRL. Since Model 2 excludes all advanced and CR courses from the analysis, those terms drop from the equation.

APPENDIX III: RESULTS

UNDERSTANDING THE LOGIT MODEL OUTPUT

Full results for all four courses can be found on the next page. The output can be understood as the logarithmic odds ratio for a set of student characteristics. To translate the ratio into a percentage, we can use the following equation:

probability of passing = $\frac{1}{1+e^{-z}}$, where z is the odds ratio calculated below.

As an example, let's examine the probability of a student passing an English I EOC test after taking the course in a traditional classroom. Let's say the student is a non-EC and non-AIG female, living in a rural area, not on FRL, and currently in ninth grade. The course is not advanced or credit recovery.

The statistical analysis shows that such a student has a 92.5% probability of passing the EOC test. This can also be described as the odds ratio, which is just the ratio of the odds of something occurring to something not occurring. In this case, the odds of passing are 0.925 to 1, while the odds of not passing are 0.075 to 1. Thus, we calculate the odds ratio as follows:

odds ratio = 0.925/0.075 = 12.418 (Step 1)

The possible odds ratio extends from 0 to 1 when the odds of something occurring are low and from 1 to infinity where the odds are high. This asymmetrical distribution creates estimation problems, so we can take the natural logarithm of the odds ratio to correct the issue. This step creates a unit called a "logit."

logit = ln(12.418) = 2.519 (Step 2)

As we can see from Appendix Table 1, Model 1 estimates a baseline constant for the sort of student described above as 2.519.

We can calculate this in reverse as well. Let's say we wanted to calculate the probability of the same female student passing a NCVPS course. We would first sum the applicable coefficients from Appendix Table 1. In this case, we would add the coefficient for NCVPS to the constant:

sum of coefficients = -0.735 + 2.529 = 1.784 = logit

We use an exponential function (the inverse of the natural log) to calculate the odds ratio:

odds ratio = $e^{1.784}$ = 5.955 (Step 2 reversed)

To calculate the odds of passing we can reverse step 1 from above:

odds ratio = 5.95 = x/(1-x) x = 0.856 (Step 1 reversed)

Thus, the probability of the female student from above passing her EOC after taking the course through NCVPS is 85.6%, as reported in Table 2 in the main paper.

RESULTS FOR MODELS 1 AND 2 ON PAGE 11

APPENDIX TABLE 1: MODEL 1 – OVERALL LOGIT REGRESSION RESULTS

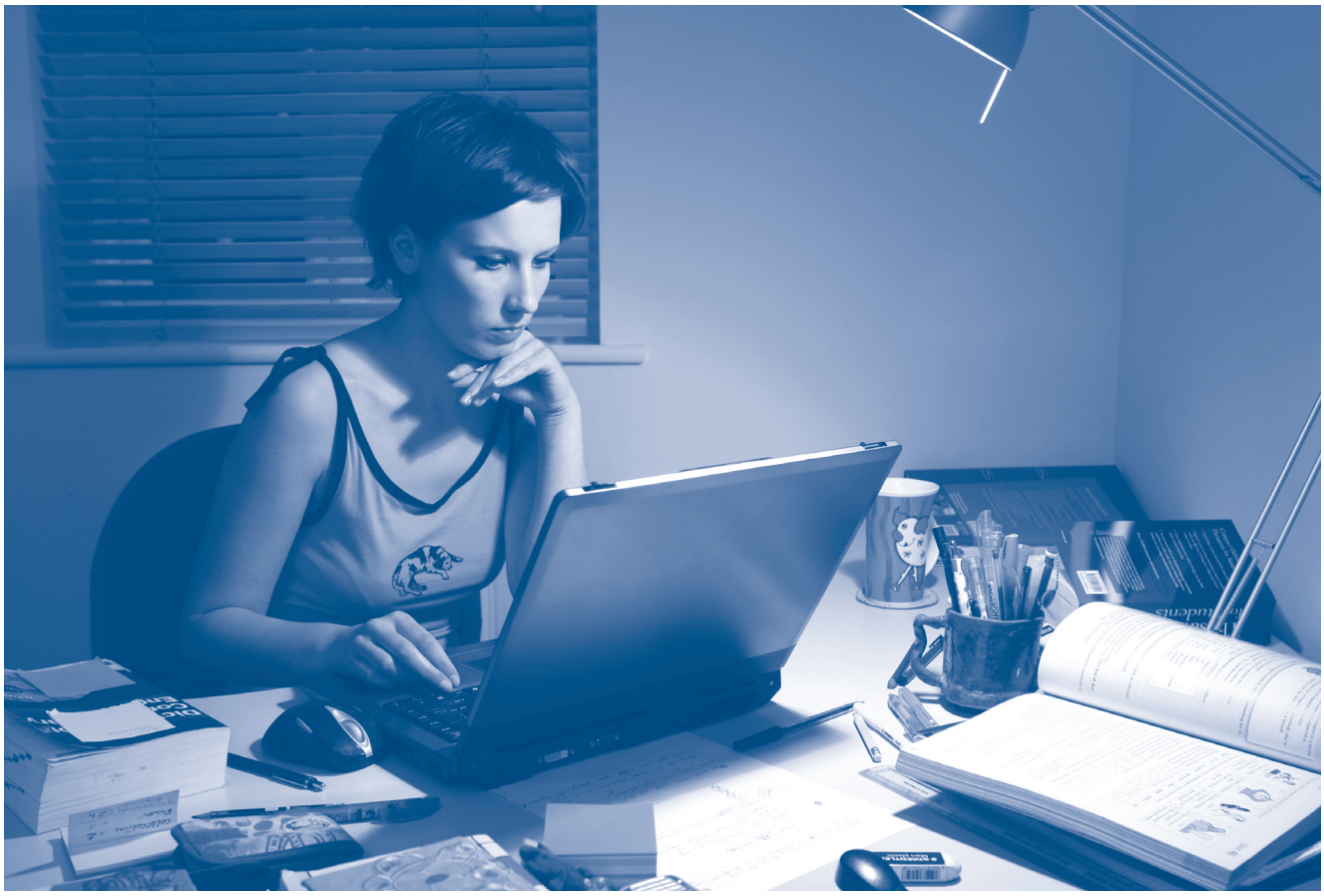
	Algebra I	English I	Civics & Economics	Physical Science
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
VPS (0,1)	-0.832***	-0.735***	-1.042***	-0.999***
	(0.213)	(0.252)	(0.186)	(0.174)
AP/IB/Honors (0,1)	0.460***	1.834***	2.173***	0.330***
	(0.057)	(0.035)	(0.029)	(0.072)
VPS X AP/IB/ Honors	(omitted)	-1.134	-0.141	(omitted)
		(0.835)	(0.402)	
Credit Recovery (0,1)	-1.279***	-1.261***	-1.486***	-3.232***
	(0.219)	(0.158)	(0.316)	(0.643)
VPS X Credit Recovery	0.804**	1.196***	0.914**	1.939***
	(0.347)	(0.347)	(0.410)	(0.702)
FRL (0,1)	-0.499***	-0.701***	-0.502***	-0.384***
	(0.018)	(0.022)	(0.019)	(0.024)
Male (0,1)	-0.094***	-0.348***	0.372***	0.075***
		(0.019)	(0.018)	(0.022)
Minority (0,1)	-0.666***	-0.913***	-0.933***	-0.737***
		(0.022)	(0.020)	(0.025)
IEP (0,1)	-1.153***	-1.632***	-1.091***	-1.229***
	(0.022)	(0.024)	(0.026)	(0.030)
AIG (0,1)	2.315***	2.872***	2.271***	1.480***
	(0.083)	(0.141)	(0.359)	(0.394)
Middle School (Grades 6-8) (0,1)	1.511***	-0.189	0.750	-0.987***
	(0.043)	(0.212)	(0.868)	(0.281)
Grade 9 (0,1)	(omitted)	(omitted)	-0.962***	-0.436***
			(0.032)	(0.043)
Grade 10 (0,1)	-0.844***	-1.106***	(omitted)	-0.312***
	(0.019)	(0.045)		(0.026)
Grade 11 (0,1)	-1.083***	-1.131***	-0.364***	(omitted)
	(0.034)	(0.105)	(0.026)	
Grade 12+ (0,1)	-1.081***	-0.599***	0.142***	-0.182***
	(0.068)	(0.205)	(0.036)	(0.032)
Rural (0,1)	(omitted)	(omitted)	(omitted)	(omitted)
Town (0,1)	-0.094***	-0.038	0.001	0.085**
	(0.025)	(0.030)	(0.027)	(0.035)
Suburb (0,1)	0.208***	0.289***	0.338***	0.118***
	(0.026)	(0.031)	(0.029)	(0.036)
City (0,1)	-0.094***	0.082***	0.097***	-0.290***
	(0.020)	(0.024)	(0.022)	(0.029)
Constant	2.083***	2.519***	1.603***	2.176***
	(0.020)	(0.026)	(0.021)	(0.029)
R-Squared	0.200	0.272	0.221	0.074
N	113,238	107,732	101,084	50,760

** p-value <0.10, ** p-value <0.05, *** p-value <0.01*

APPENDIX TABLE 2: MODEL 2 – FRL LOGIT REGRESSION RESULTS

	Algebra I	English I	Civics & Economics	Physical Science
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
VPS (0,1)	-0.090**	-0.931*	-1.052***	-0.727***
	(0.043)	(0.485)	(0.255)	(0.238)
FRL (0,1)	-0.073***	-0.65	-0.462***	-0.376***
	(0.003)	(0.022)	(0.020)	(0.024)
VPS X FRL	-0.086	0.259	0.048	-0.657*
	(0.081)	(0.565)	(0.365)	(0.360)
Male (0,1)	-0.012***	-0.328***	0.368***	0.073***
	(0.002)	(0.020)	(0.019)	(0.023)
Minority (0,1)	-0.096***	-0.895***	-0.907***	-0.736***
	(0.003)	(0.023)	(0.021)	(0.026)
IEP (0,1)	-0.230***	-1.581***	-1.062***	-1.225***
	(0.005)	(0.024)	(0.026)	(0.031)
AIG (0,1)	0.070***	2.558***	(omitted)	1.467***
	(0.002)	(0.161)		(0.395)
Middle School (Grades 6-8) (0,1)	0.103***	-0.199	0.674	-0.992***
	(0.002)	(0.212)	(0.884)	(0.281)
Grade 9 (0,1)	(omitted)	(omitted)	-1.047***	-0.481***
			(0.035)	(0.044)
Grade 10 (0,1)	-0.181***	-1.085***	(omitted)	-0.327***
	(0.004)	(0.046)		(0.027)
Grade 11 (0,1)	-0.241***	-1.161***	-0.370***	(omitted)
	(0.008)	(0.108)	(0.026)	
Grade 12+ (0,1)	-0.242***	-0.624***	0.137***	-0.180***
	(0.016)	(0.212)	(0.037)	(0.032)
Rural (0,1)	(omitted)	(omitted)	(omitted)	(omitted)
Town (0,1)	-0.016***	-0.070**	-0.016	0.075**
	(0.004)	(0.031)	(0.029)	(0.035)
Suburb (0,1)	0.028***	0.298***	0.329***	0.122***
	(0.003)	(0.032)	(0.030)	(0.037)
City (0,1)	-0.018***	0.044*	0.076***	-0.300***
	(0.003)	(0.025)	(0.024)	(0.029)
Constant	0.896***	2.463***	1.576***	2.183***
	(0.002)	(0.027)	(0.022)	(0.029)
R-Squared	0.181	0.143	0.095	0.071
N	109,000	63,538	60,181	48,878

** p-value <0.10, ** p-value <0.05, *** p-value <0.01*



Works Cited

- Bernard et al. (2004). How does Distance Education Compare with Classroom Instruction? A Meta-Analysis of the Empirical Literature. *Review of Educational Research, 74 (3)*, 379-439.
- Clotfelter, C., Ladd, H. F., & Vigdor, J. (2010). "Teacher Credentials and Student Achievement in High School: A Cross-Subject Analysis with Student Fixed Effects." *Journal of Human Resources. 45(3)*, 655-681.
- Fryer, R. G., & Levitt, S. D. (2006). "The Black-White Test Score Gap Through Third Grade." *American Law and Economics Review. 8(2)*, 249-281.
- Kember, D. (1996). Student Progress in Distance Education: Identification of Explanatory Constructs. *British Journal of Educational Psychology, 62 (3)*, 285-298. DOI: 10.1111/j.2044-8279.1992.tb01023.x
- North Carolina Virtual Public Schools (2010). "Courses." Retrieved from http://www.ncvps.org/index.php/courses/
- Oliver, K., Osborne, J., Patel, R., & Kleiman, G. (2009a). "Issues Surrounding the Development of a New Statewide Virtual Public Schools." *The Quarterly Review of Distance Education.* 10(1), 37-49.
- Oliver, K. M., Brady, K., Patel, R., & Townsend, T. (2009b). 2008-2009 Evaluation Report: North Carolina Virtual Public School. Raleigh, NC: William and Ida Friday Institute for Educational Innovation.
- Reardon, S. F. & Robinson, J. P. (2008). "Patterns and Trends in Racial/Ethnic and Socioeconomic Academic Achievement Gaps." In H. F. Ladd & E. B. Fiske (Eds.). *Handbook of Education Finance and Policy* (497-516). New York: Routledge.
- Rothstein, R. (2004). Class and Schools: Using Social, Economics, and Educational Reform to Close the Black-White Achievement Gap. Washington: Economic Policy Institute.
- Sipple, J. W., & Brent, B. O. (2008). "Challenges and Strategies Associated with Rural School Settings." In H. F. Ladd & E. B. Fiske (Eds.). *Handbook of Education Finance and Policy* (612-630). New York: Routledge.

By Angel Banks, Candice Bodkin, and Jennifer Heissel

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